# ELECTRICAL ENGINEERING

APRIL 1942

AIEE NORTH EASTERN DISTRICT MEETING, SCHENECTADY, N. Y., APRIL, 29–MAY 1, 1942

# O-B
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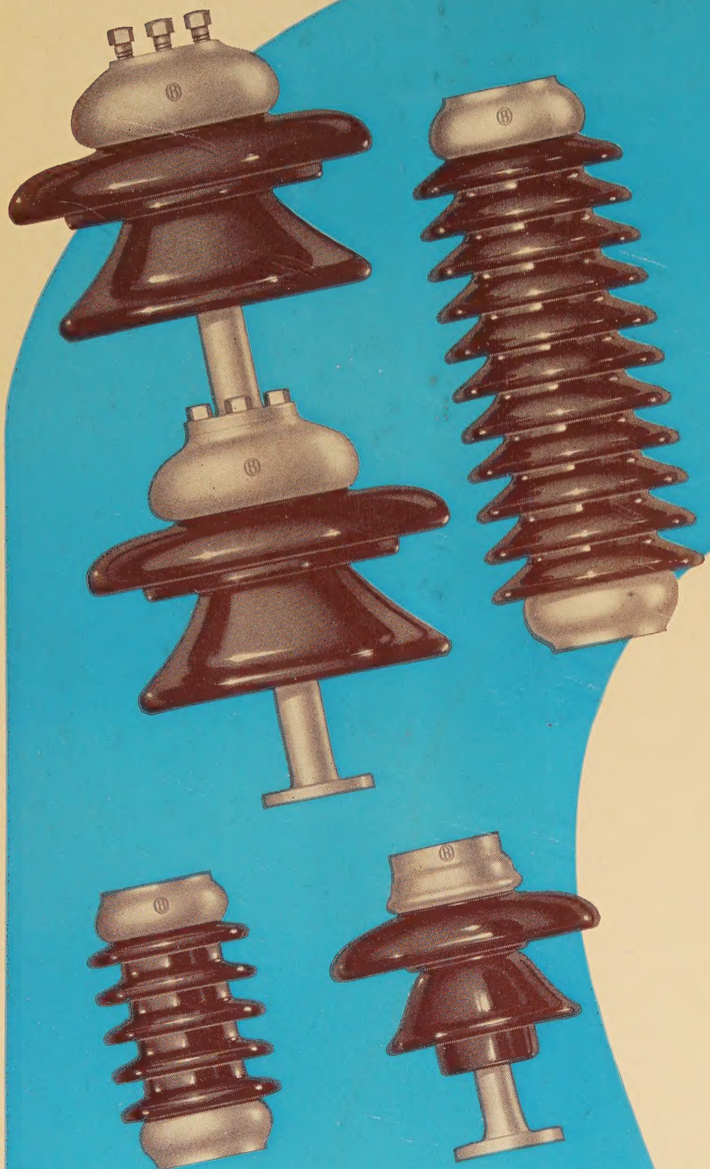
## Station Insulators Meet New Impulse Coordination Requirements



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BASIC impulse insulation levels have been established as standards of reference by the joint A.I.E.E.-E.E.I.-NEMA Committee on the Coordination of Insulation, and O-B has designed a complete line of switch and bus insulators conforming to the new standards. Having "BIL" station pincaps and posts in all sizes, and with threaded or slotted caps, O-B can furnish the proper insulators for any station in which the apparatus insulation is to be completely coordinated. All of these insulators are free of radio interference, properly designed, built to the highest standards and thoroughly tested. That means you can depend on O-B's "basic insulation level" units to provide the trouble-free service required of wartime insulators.

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# ELECTRICAL ENGINEERING

Registered U. S. Patent Office

APRIL
1942

**The Cover:** Outdoor mercury-steam-electric power plant of General Electric Company, Schenectady, N. Y.; completed in 1933, the plant has undergone considerable development since that time. A conference on mercury power plants is scheduled for the AIEE North Eastern District meeting at Schenectady, April 29–May 1, 1942



## TRANSACTIONS SECTION

*(Follows EE page 228; a preprint of pages 169–232 of the 1942 volume)*



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# HIGH LIGHTS • •

**Lightning Investigations.** Reports of lightning investigations on three widely separated electric-power systems are included in this issue. The first two present the latest information obtained on continuing investigations on a 220-kv line in northeastern Pennsylvania (*Transactions pages 196–201*), and a large middlewestern 132-kv system (*Transactions pages 178–85*). The third investigation reported was made on a 100-kv line in Colorado at altitudes ranging from 6,000 to 13,500 feet (*Transactions pages 201–08*).

**Wartime System Planning.** A large eastern electric-power system has experienced a load growth during the past three years of about 12 per cent per year—a phenomenon not experienced since 1929. System-planning procedures to accommodate this increase in load and to accommodate future sharp increases resulting from the wartime production, at the same time conserving critical materials, are outlined in an article in this issue (*pages 192–6*).

**Burying Telephone Cables.** In recent years there have been extensive developments in the art of burying telephone cables. The cable plow is operated as a member of a train consisting of four Diesel caterpillar tractors, a rooter plow which precedes the cable plow, and two caterpillar-type cable-reel trailers which follow it. All this equipment, weighing more than 100 tons, travels at the rate of a brisk walk, burying the cable as it goes (*Transactions pages 169–74*).

**PCC Car Operation.** Experience with PCC (Presidents Conference Committee) trolley cars in Pittsburgh, Pa., has demonstrated that their use has reduced car maintenance 28 per cent, track and roadway maintenance 21 per cent, accidents 25 per cent, and the number of cars required for specific schedules 10 per cent; revenues have increased 8 per cent (*Transactions pages 214–17*).

**Schenectady Meeting.** The program of the AIEE North Eastern District meeting to be held at Schenectady, N. Y., April 29–May 1 includes seven conference sessions and an unusually large number of special features, in addition to a general session, three technical sessions, and a student session (*pages 206–09*). Abstracts of papers to be available in pamphlet form also are included in this issue (*pages 210–11*).

**Car Lighting.** Rapid advances have been achieved in the lighting of railroad passenger cars since 1935, when the application of air conditioning opened the way to a radical change in car lighting. Subsequently fluorescent lamps have been applied to cars, and future developments are expected to center upon improved applications of these lamps (*pages 179–86*).

**Meter Testing.** A procedure for factory testing of watt-hour meters developed by one manufacturer makes use of the stroboscope within its practical limits, photoelectric methods of revolutions counting, and a system for obtaining simultaneous readings of watt-hour-meter calibration accuracy at three load points (*Transactions pages 218–23*).

**Single-Phase Locomotives.** Automatic and semiautomatic protective devices are required on electric locomotives, and also indicating devices to which attention must be directed during operation. In addition it is necessary also to predetermine the maximum load that a locomotive can handle over each route without overheating (*Transactions pages 224–8*).

**Laplacian Transform Analysis.** This month's installment on advanced mathematics as applied to electrical engineering, third in a series of five articles, discusses Laplacian transform analysis of circuits with linear lumped parameters. The method is said to be applicable also to circuits having distributed parameters (*pages 197–205*).

**Electric Strength of Nitrogen and "Freon."** In 60-cycle dielectric tests at pressures from one to several atmospheres, Freon is found to withstand much higher voltages than either air or nitrogen. A small percentage of Freon gas in nitrogen produces an anomalously large rise in the electric strength (*Transactions pages 191–5*).

**Trolley-Coach Overhead.** Development of overhead equipment for trolley-coach operation during the past 20 years has been concentrated mainly on current collection, hangers and insulation, curve materials, and turnouts and crossovers. Progress achieved is reflected in the present higher service standards (*Transactions pages 185–91*).

**Control of Governors.** Speed governors of prime movers have always provided the medium for supplementary control of frequency, load, and time, in interconnected power systems; characteristics and functions of the supplementary control devices are discussed in a paper in this issue (*Transactions pages 209–13*).

**Progress in Lightning Protection.** The third and last of a series of related articles reviewing progress during the last decade in the protection of electric-power-system circuits and equipment covers the progress in protection against lightning, lightning surge devices, and limitation of fault current (*pages 187–92*).

**Transient Recorder.** A transient recorder has been developed, employing magnetic-tape recording as a means of preserving a record of the transient, and then steadily repeating this record on the screen of a cathode-ray oscilloscope (*Transactions pages 175–7*).

**Industrial Locomotives.** New and improved insulating materials and varnishes, together with new design constants have made possible reduced weight per horsepower in industrial Diesel-electric locomotives and an improved product (*Transactions pages 229–32*).

**Navy Training Program.** An educational program to keep young men in college to the limit of their ability and at the same time provide the Navy with 80,000 or more specially trained young men per year has been announced (*pages 218–19*).

**War Contracts for Small Manufacturers.** The biggest mistake any manufacturer can make is to assume he hasn't a chance of getting war contracts, says the division of industry operations of the War Production Board (*pages 222–3*).

**Coming Soon.** Among special articles and technical papers currently in preparation for early publication are: an article on "the second mile" in the engineering profession by W. E. Wickenden (F'39); the fourth article in the series on advanced mathematics applied to electrical engineering, on analysis of systems with known transmission-frequency characteristics by Fourier integrals by W. L. Sullivan (A'34); an article on wind shielding of parallel conductors by G. D. Sheckels (A'39); a paper on transient characteristics of current transformers during faults by C. Concordia (M'37), C. N. Weygandt (A'37), and H. S. Shott (A'40); a paper on the design of long-scale instruments by A. J. Corson (A'24), R. M. Rowell (A'42), and S. C. Hoare (A'42); a paper discussing loss-of-field protection for generators by G. C. Crossman (M'42), H. F. Lindemuth (M'41), and R. L. Webb (M'35); a report on field investigations of the characteristics of lightning currents discharged by arresters by I. W. Gross (M'40), G. D. McCann (A'38), and Edward Beck (M'35); a paper on linear couplers for bus protection by E. L. Harder (M'41), E. H. Klemmer, W. K. Sonnemann (A'38), and E. C. Wentz (A'28); a paper on the modified Kramer or asynchronous-synchronous cascade variable-speed drive by M. M. Liwschitz (M'39) and L. A. Kilgore (M'37); a paper describing a $2^1/_2$-million-kva compressed air powerhouse breaker by L. R. Ludwig (M'41), H. M. Wilcox (M'27), and B. P. Baker (M'41); and a paper on correction for saturation by T. C. McFarland (M'32).

# Modern Railroad-Car Lighting

W. S. H. HAMILTON
MEMBER AIEE

**From 1905, when electric lighting first was applied to railroad passenger cars, until 1935, no radical change in car-lighting practices occurred. Since 1935, however, when the application of air conditioning permitted a radical change to be made in the lighting, developments have been accelerated, paralleling those in the lighting field itself. These later developments are reviewed in this article, which outlines the present status of both incandescent and fluorescent car lighting and points to several possible future developments in fluorescent car lighting. Although based primarily upon developments on one railroad, it is believed to be representative of progress throughout the industry.**

RAILROAD-CAR LIGHTING has taken some remarkable strides forward in the last few years and is now on the threshold of even greater achievements due to the advent of fluorescent lamps. Before considering the present and probable future, however, it might be interesting to take just a glance at the past.

In the days of the "gay nineties" before calories, vitamins, short skirts, and bobbed hair were even dreamed of, and when travelers were a hardy lot, inured to heat and cold, dust and cinders, lighting was accomplished by means of kerosene, gasoline, or Pintsch gas lamps, usually arranged in the center of the car and rather ornately constructed, as may be noted in Figure 1. As the pocket foot-candle meter had not then been developed, the car-lighting engineer did not have to worry too much about the amount and distribution of light, although such systems were no doubt a great improvement over the candles that had preceded them. A number of Pintsch gas-lighted cars are still in service on certain railroads. The gas is stored in tanks under the cars, and the burners somewhat resemble ordinary gas burners, both flat-flame and mantle types being used.

## ADVENT OF ELECTRIC LIGHTING

After 1905, however, the electric-lighted car was introduced on a large scale, and development proceeded until the car shown in Figure 2 was reached. This type remained more or less unchanged until about 1935, when the application of air conditioning permitted a radical change to be made.

The lighting fixtures in Figure 2 are mounted approximately one over every other seat, making 21 fixtures for the body of the car. The shades are of the open-mouth glass type, well designed for light distribution, sending most of it downward while still allowing enough to go upward to illuminate the ceiling properly. A 25-watt 30- or 32-volt lamp is used in each fixture, and with lamps at full voltage approximately three foot-candles is obtained on the 33-inch 45-degree reading plane (this is a plane 33 inches above the floor, inclined at an angle of 45 degrees).

The connections of the generator, battery, and other equipment are shown in Figure 3. The generator is usually a two-kilowatt 40-volt machine and the battery 300 ampere-hours. It should be borne in mind, however that these generators must deliver constant voltage over approximately a four-to-one range in speed so that their physical size is greater than that of a two-kilowatt constant-speed machine. Also they are totally enclosed as protection against dirt and water, which increases their size.

The question naturally arises: "Why did this system stay so nearly the same for practically 30 years?" There are three reasons for this: First, there was a progressive improvement in the efficiency of the lamps used, which approximately doubled the light output during this period; second, the cost of the generator, battery, and associated equipment was approximately $1,000, and any further increases in illumination meant new generators and batteries with the cost directly chargeable to the improved lighting; and third, the flat-belt drives used for driving the generators from the axles will not satisfactorily drive generators over five kilowatts in capacity, especially in the north where snow is present in winter, and are not too good at that capacity.

## AIR CONDITIONING AND ITS EFFECT ON LIGHTING

About 1935 air conditioning was introduced on a large scale, and the so-called electromechanical system was widely adopted. This is shown diagrammatically in Figure 4. In this system the air-conditioning compressor is electric-motor driven, hence its name. Because of the power required by this motor-driven compressor, the generator capacity had to be increased to 20 kw at 80 volts, as shown in Figure 4, and the battery to 32 cells of 600 ampere-hours (lead) or four times as large as the battery in Figure 3. (When a 40-volt generator is used the battery consists of 16 cells of 1,200

Based upon an address delivered originally at a joint meeting of the transportation and illumination groups of the AIEE New York Section, April 10, 1941.

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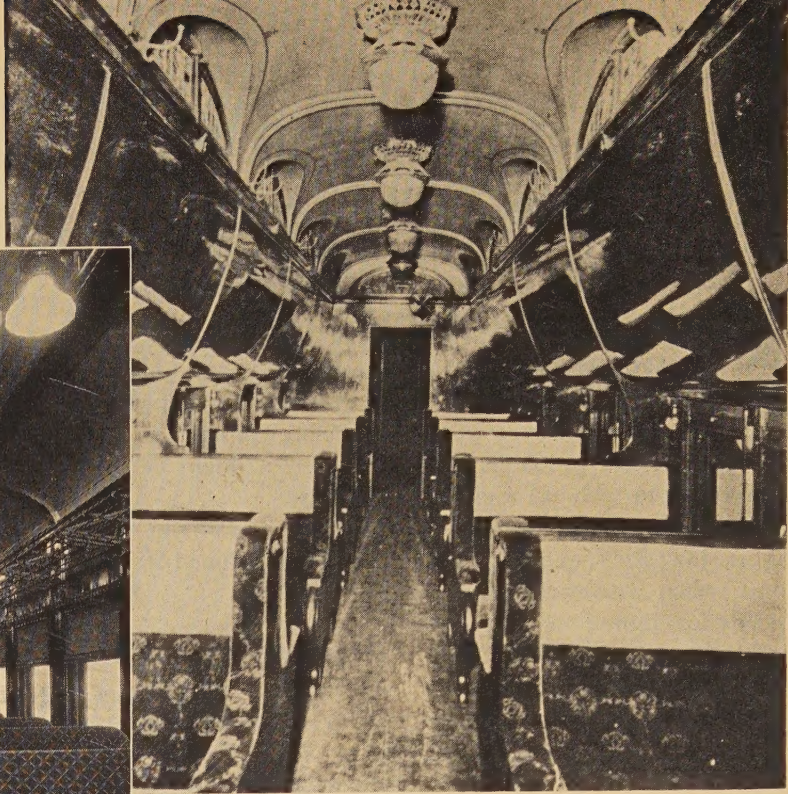
The author acknowledges the help given by his many friends in connection with this article, without which its preparation would have been difficult, if not impossible.

Figure 1 (right). Pintsch-gas-lighted sleeping car

Figure 2 (below). Standard non-air-conditioned coach with lighting of period 1905–35



ampere-hours.) The large generator and battery made possible a substantial increase in the lighting, as may be noted by comparison between Figures 3 and 4, and it was possible to make this increase without charging any expense to the lighting except that of new fixtures when used. This increase in lighting was secured by providing a 40-watt lamp over every seat. Figure 5 shows a coach relighted in 1937 with this arrangement,[1] and Figure 6 a new coach built in 1941, the lamp loads being those shown in Figure 4. The coach of Figure 5 has from 8 to 10 foot-candles at the 33-inch 45-degree reading plane and that of Figure 6 about 15 foot-candles.

### DEVELOPMENT OF MODERN LIGHTING

Some experimenting was necessary before the arrangements of Figures 5 and 6 were selected. In the fall of 1936, test installations were made in three cars, the fixtures being mounted on the deck in relatively the same positions as those of Figure 2. It was determined that a 40-watt lamp per fixture would give satisfactory illumination. Incidentally this required the development of a new size of lamp for car-lighting service and one which is now available for both 60 and 30 volts.

Part of the pressure for increased lighting came from the greater cleanliness of the air-conditioned cars, as it is only natural to expect lighting to be in keeping with the general appearance of the car interior. It is hard to keep fixtures clean in cars in which cinders and dust are prevalent, and dirty fixtures discourage improvement in lighting.

Experience was also gained from work on the de luxe trains, "The Mercury,"[2] which was placed in service in 1936 (Figure 7), and the "Twentieth Century"[3] (Figure 8). However, the lighting systems on such trains are de luxe installations and in general not suitable for ordinary cars, especially coaches.

Sometimes considerable improvement can be made in illumination without installing new fixtures. A number of coaches were air-conditioned in 1941 in which the existing lighting fixtures were retained. By tinting the shades an amber color on the outside, and increasing the lamps from 25 to 40 watts, it was found that with the lowered ceilings and light wall colors used, the illumination was brought up to approximately 8.5 foot-candles at the 33-inch 45-degree reading plane, and the appearance was very pleasing (see Figure 9).

### GENERAL REQUIREMENTS OF MODERN LIGHTING

By modern lighting is meant from 7 to 15 foot-candles at the 33-inch 45-degree reading plane in coaches and about the same or more in other types of passenger cars. These are lighting intensities recommended by the electrical section, mechanical division, Association of American Railroads.[5] The fixtures to produce this result must:

1. Direct most of the light downward to the reading plane.

2. Direct enough light onto the ceiling to illuminate it properly. This is very important as too dark a ceiling gives the impression of a poorly lighted car and tends to create a glaring condition, by accentuating the brightness of the fixtures.

3. Eliminate glare when fixtures are viewed from positions other than directly beneath them. As the intensity of illumination is increased this becomes more and more important.

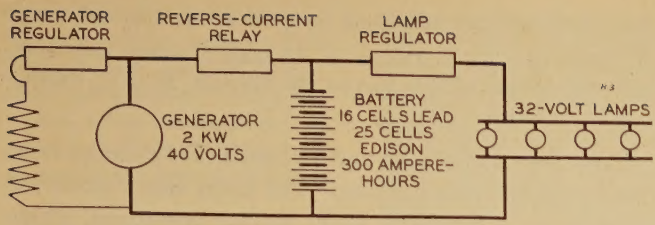



**Figure 3. Schematic diagram of typical axle-generator system, non-air-conditioned coaches**

| | Load in Watts |
|---|---|
| Body lights | 525 |
| Other lights | 150 |
| Lamp regulator loss | 125 |
| Total | 800 |

Three different methods of accomplishing these results are shown by the fixtures of Figure 10. All three accomplish the same result, although there are some differences in efficiencies. It is important that any fixture used have an ample-sized light-transmitting opening, as otherwise the full benefit will not be gained from the fixture.

Other means also have been used, such as louvers, particularly in continuous-type trough fixtures;[6,7] and plastic shades. Indirect lighting has also been used. The car in Figure 7 has fixtures that give both direct and indirect lighting. Indirect lighting alone, however, is not very efficient when compared with direct lighting from well designed fixtures.

The best location for lighting fixtures in coaches is under the baggage racks,[8] as shown by Figure 6, if suitable supplementary lighting is provided to give adequate ceiling illumination; this location brings the lights close to reading plane and also permits providing individual control by the passengers. This arrangement, however, is seldom feasible except on new cars, because of the cost of installation.

## NIGHT LIGHTING

With air conditioning and modern lighting, reclining seats also were introduced on a number of coaches and more extensively used than previously. With these came a demand for reduced lighting for use late at night in order to permit passengers to sleep without being disturbed by the bright lights. A number of arrangements have been used for this purpose, including: dimming of some of the main lighting units, with the others extinguished; small additional fixtures installed especially for the purpose,[1] as may be noted in Figure 5; and the use of an auxiliary low-wattage lamp in the main fixtures, usually blue in color.

At present the trend is definitely toward providing low-wattage (6 to 10 watts) blue lamps either in some of the main fixtures or in auxiliary fixtures provided for the purpose. The cars of Figures 9 and 18 have center lighting fixtures with 25-watt incandescent lamps and 10-watt blue lamps, with transfer switches arranged to permit the selection of either as desired. Late at night the body lights are extinguished and the blue lights alone used for illumination in the body of the car. Platform, salon, and passageway lights are left unchanged, but shields are provided where necessary to prevent any direct view of the passageway lights from the body of the car.

## INCIDENTAL EFFECTS OF MODERN LIGHTING

Improvement of the body lighting led to an increase in the lighting in washrooms and salons, while the use of air conditioning led to improved ventilation by installation of exhaust fans; as a result, the total load for purposes other than the air-conditioning compressor on cars of the type of Figure 6 is approximately 3,500 watts as compared with the 800 watts of Figure 3. Not only has the total load increased, but also the loss in the lamp regulator, which in turn requires improved ventilation of regulator lockers. Even with the large-sized batteries used on air-conditioned cars, the effect of these high lighting loads becomes noticeable.

In short, the increased lighting load required by modern lighting indicates decidedly the desirability of a source of light more efficient than the incandescent lamp, which is the only type so far considered in this article.

## FLUORESCENT LAMPS

Fluorescent lamps were first placed on the market in April 1938 and have had widespread acceptance for many uses since that time. Most readers are no doubt familiar with their operation, especially on 115-volt a-c circuits,[9–13] so that in this article only their use for car lighting is considered.

The possibilities for power saving are immediately apparent. An 18- by $1^1/_2$-inch (T-12) 3,500-degree white fluorescent lamp with 15 watts input to the lamp and about 5 watts loss in the auxiliary, or a total input from the line of 20 watts, gives about four per cent more light than a 40-watt 60-volt incandescent lamp. Therefore, *exclusive of conversion losses*, the power required can be cut in half for approximately the same light.

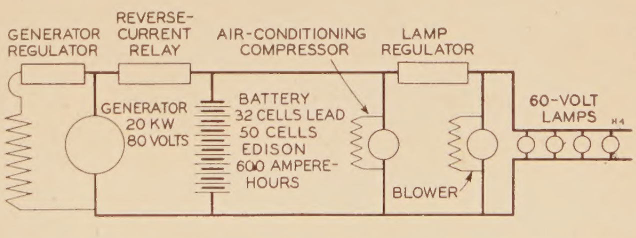



**Figure 4. Schematic diagram of typical axle-generator system air-conditioned coaches**

| | Load in Watts | |
|---|---|---|
| | 1937 | 1941 |
| Air-conditioning compressor | 11,400 | 11,400 |
| Blower and exhaust fans | 720 | 840 |
| Body lights | 1,200 | 1,350 |
| Other lights | 410 | 755 |
| Lamp regulator loss | 430 | 555 |
| Total | 14,160 | 14,900 |

Fluorescent lamps have other advantages:

1. The light is much more evenly distributed than with an incandescent lamp, due to the larger source of illumination.

2. The effect of voltage variations on light output is less than with incandescent lamps, a one per cent voltage change making a 1 to $2\frac{1}{2}$ per cent change in light from a fluorescent lamp; whereas it makes a $3\frac{1}{2}$ per cent change in light from an incandescent lamp.

They also have some disadvantages:

1. The lamps will not light or stay lighted below a certain voltage.

2. Lamps operated on a-c circuits are sensitive to frequency variations, 58 to 62 cycles now being accepted as the standard range.

3. When operated on d-c circuits, the range in voltage over which they will operate is fairly narrow, for example, 55 to 62 volts for one size of lamp.

Both the 1-inch (T-8) and $1\frac{1}{2}$-inch (T-12) lamps have been used for train lighting. The latter size is preferred on account of the much lower surface brightness, which is especially desirable when the lamp is completely or partially exposed to view.

Fluorescent lamps when first brought out were designed for operation from an a-c supply only. Therefore,

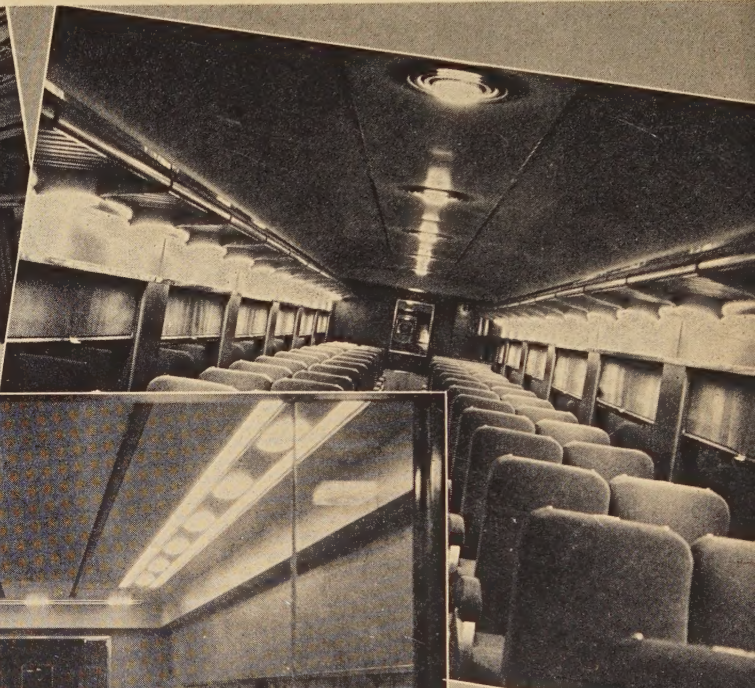
**Figure 5 (below). Air-conditioned coach with ceiling and night lights, 1937**

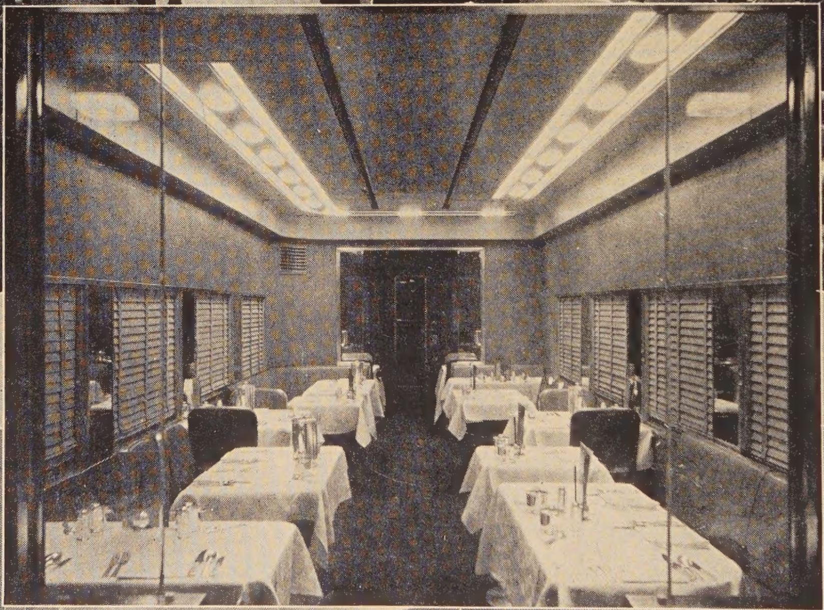
**Figure 7 (bottom). Observation car, "The Mercury," 1936**

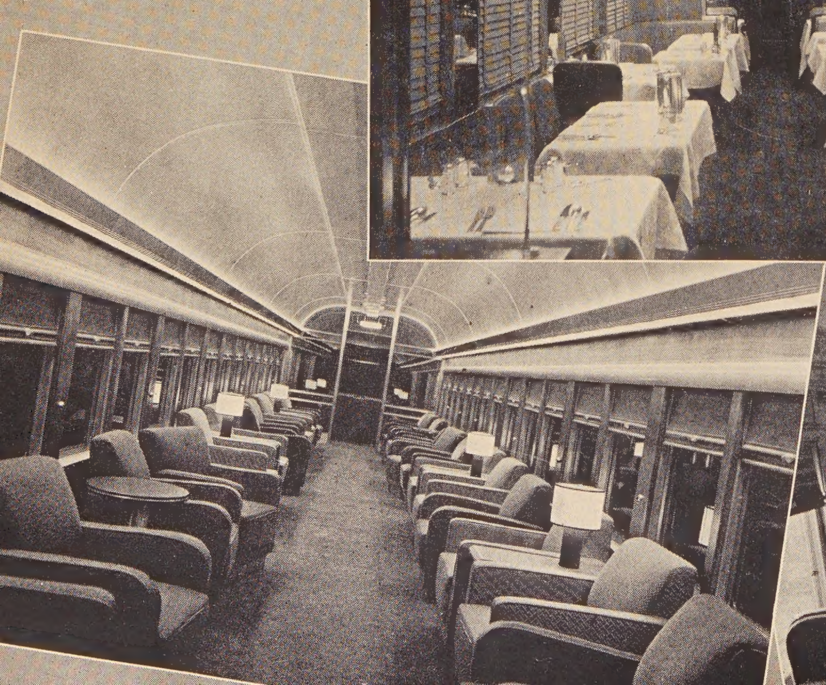
**Figure 8 (center). Dining car, "Twentieth Century Limited," 1938**

**Figure 6 (below). Air-conditioned coach with ceiling and baggage-rack lights, 1941**

**Figure 9 (bottom). Air-conditioned coach with original fixtures and ceiling lights, 1941**







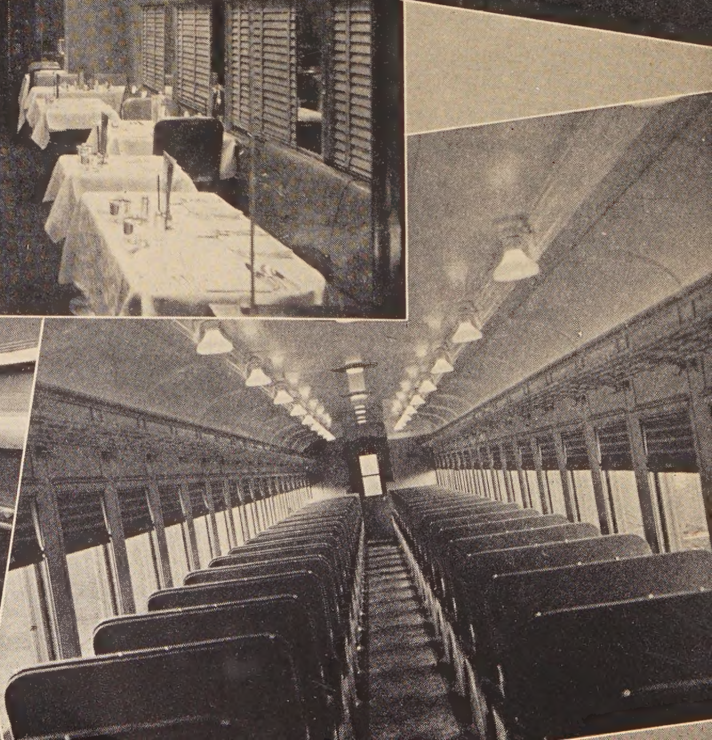
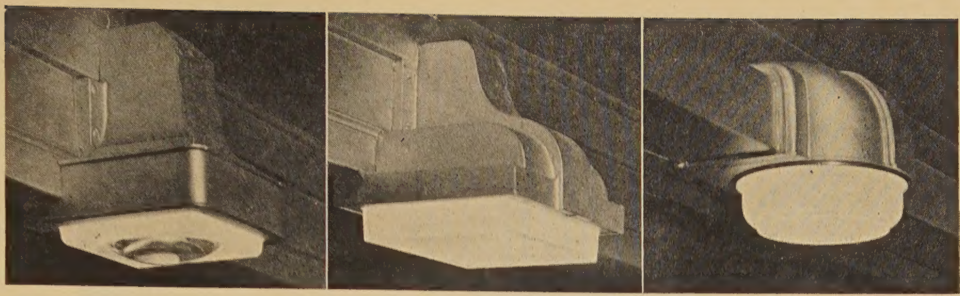


**Figure 10. Three types of car-lighting fixtures utilizing (left) a single lens, (center) a multiple or prismatic lens, and (right) cross-hatching in the glass at the bottom of the bowl to control the light distribution**



for car lighting some device was required to convert from direct to alternating current, and most of the problems have been associated with these conversion devices.

The first application of fluorescent lamps to train lighting was to the rear-end signs[4] of the "Twentieth Century Limited" placed in service June 15, 1938, and shown in Figure 11. Four 18- by $1\frac{1}{2}$-inch (T-12) blue lamps are used in each sign, operated on alternating current, 115 volts, supplied by a small rotary inverter. A deep shade of blue was desired for the background of these signs, and these lamps are particularly adapted to produce this color. They also require only a very low input as compared with incandescent lamps. The results of this installation were very successful, and a number of similar signs have since been placed in service on other trains. No difficulty has been experienced in operating these signs in cold weather which sometimes causes fluorescent lamps to fail to start. This is probably due to the tubes being enclosed within the sign.

As a result of this successful application to the signs, an application of fluorescent lamps for lighting the body of a coach[14] was made in September 1938 as shown in Figure 12, this being the first car in the United States to be so equipped. The car is a non-air-conditioned coach similar to the one in Figure 2, with a fixture for an 18- by $1\frac{1}{2}$-inch (T-12) lamp over every seat. Alternating current at 115 volts was first obtained from a rotary commutator inverter but later from vibrator inverters. The installation of these fluorescent lamps increased the total load on the car from 800 to 1,000 watts and the illumination from 3 to 11 foot-candles. The original generator and battery, however, were large enough to handle the increased load. The even illumination and the absence of shadows is especially noticeable in this car.

Another installation[15] is shown by Figure 13. Lamps are 18- by $1\frac{1}{2}$-inch (T-12) operating on alternating current at 115 volts, power supply being from vibrator inverters on some cars and motor alternators on others. Illumination of about 15 to 20 foot-candles is obtained at the 33-inch 45-degree reading plane.

## METHODS OF INVERSION

At present two methods of changing direct to alternating current (inversion) are used—vibrator inverters and motor alternators. Figure 14 shows schematically one type of vibrator inverter installation in which no provision is made for turning off individual lamps and hence is known as the "constant load" type.[16,17] This is the type referred to in connection with the car shown in Figure 12. Figure 14 should be understood as being schematic only, not all the connections of the vibrator being shown. Since 1938 other types of vibrators have been developed which permit the switching of individual lamps, but the connections are more complicated than those shown here.[18]

The advantages of vibrator inverters are that they have a relatively high efficiency, approximately 70 per cent, and the vibrator itself is quickly replaceable as well as being fairly inexpensive. The disadvantages are that the vibrator is subject to mechanical and electrical failures.

Figure 15 shows the connections of a motor alternator,[18,19] which is merely a small motor generator set having a single-phase generator. The set is provided with inherent regulation of voltage and speed. Standard commercial auxiliaries are used with the fluorescent lamps, those of the double-lamp type (leading and lagging power factor) being preferable, on account of the reduction of the stroboscopic effect which they provide.

The efficiency of motor alternators is less than that of vibrator inverters, being approximately 60 per cent at full load and less at light loads. On account of the relative simplicity and ruggedness of these machines, quite a number are now in use.

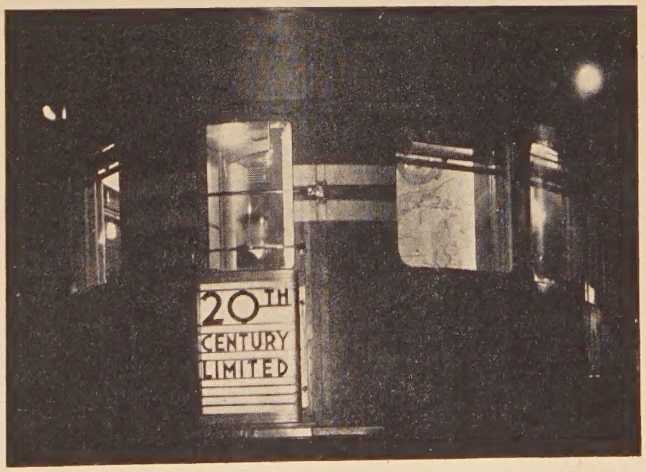



**Figure 11. Rear-end sign of the "Twentieth Century Limited," lighted by blue fluorescent lamps**

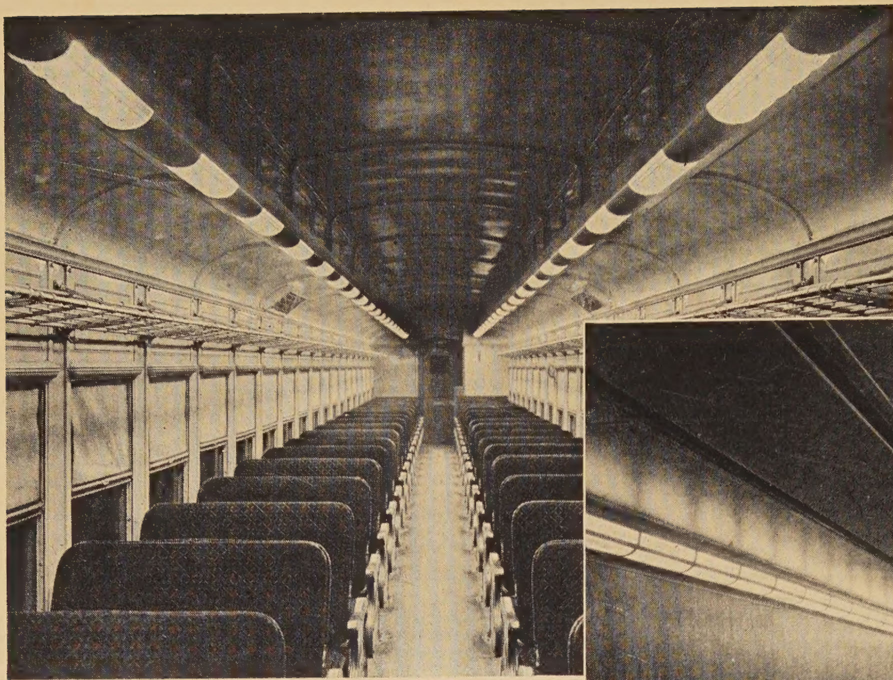


Figure 12 (left). Fluorescent-lighted non-air-conditioned coach

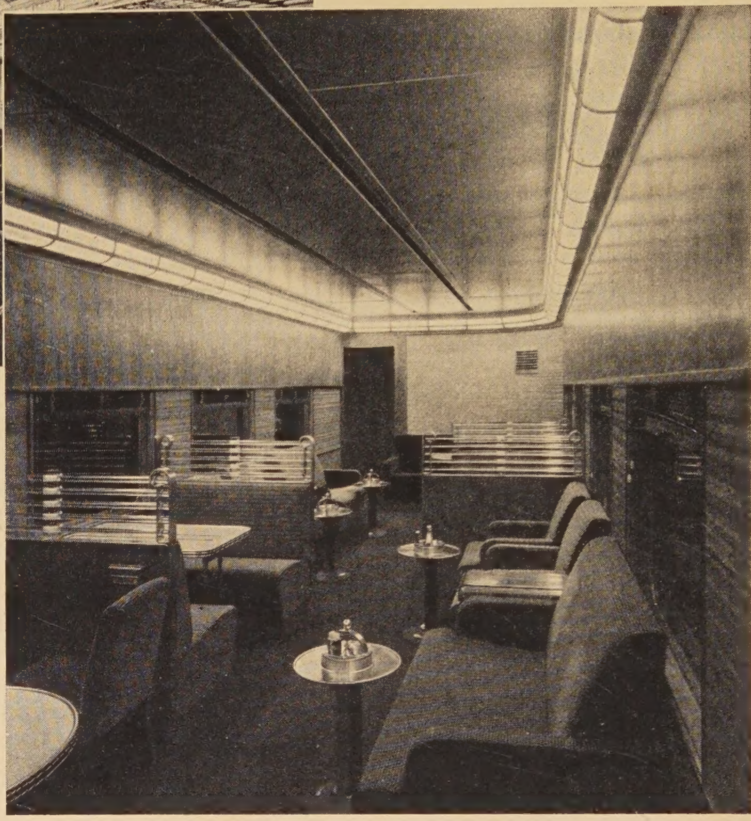


Figure 13 (below). Public space of fluorescent-lighted bedroom–lounge car

The losses in these inversion devices partly nullify the inherent efficiency of the fluorescent lamp. It may be noted that both the vibrator inverters and the motor alternators eliminate the lamp regulator, which helps to improve the efficiency. The inversion efficiency can drop to approximately 38 per cent before the input of a fluorescent-lamp installation will be increased to that of an incandescent-lamp installation for the same amount of light.

The desirability of eliminating the inversion devices soon became apparent and led to the next and very important development, namely operation of fluorescent lamps on direct current.

## FLUORESCENT LAMPS ON DIRECT CURRENT

Any fluorescent lamp will operate on direct current providing the proper voltage and current is supplied and a ballast resistance is used to prevent the lamp from taking excessive current after it has started to operate.[18] However, the range in voltage over which such lamps will operate is somewhat limited, and it is not so easy to select sizes that will operate on the car-lighting voltages available.

For the so-called 64-volt system, in which the voltage actually varies from 56 to 80 volts with lead batteries or 56 to 90 volts with Edison batteries, it was found necessary to develop a new size of lamp, 15- by $1^1/_2$-inch (T-12), in order to secure one that would start and operate on voltages down to 55 volts, which was considered as the lower limit of required operation.[20] The connections for operating the lamps are shown by Figure 16. This method of operation is very simple and permits individual control of the lamps. With 60 volts applied to the circuit, the lamp takes 16 watts and the ballast lamp and auxiliary 6 watts, a total of 22 watts. The lamp has an output of 560 lumens, which compares with 504 lumens from a 40-watt 60-volt incandescent lamp and with 525 lumens from an 18- by $1^1/_2$-inch (T-12) 3,500-degree white fluorescent lamp operating on alternating current. This lamp operating on direct current is more efficient than when operating on alternating current and has no stroboscopic effect. It is necessary however to retain the lamp regulator. Inci-

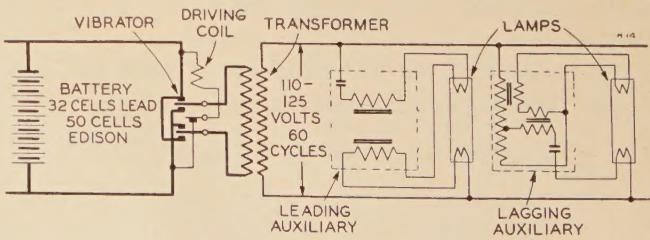



Figure 14. Typical connections for "constant load" vibrator inverter

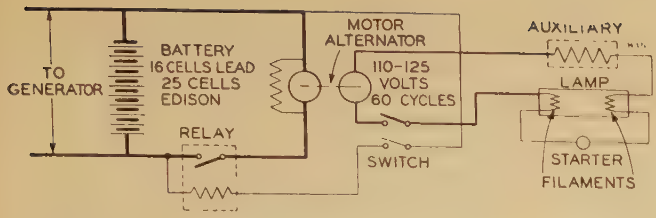



**Figure 15. Typical connections for motor alternator**

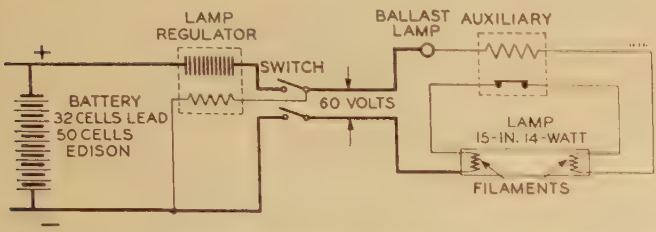



**Figure 16. Typical connections for operating fluorescent lamps on direct current**

dentally, this lamp also will operate on alternating current with the same auxiliaries as for direct current operation and at about the same voltage.

The first installation of these lamps operating on direct current was on a coach exhibited at the New York World's Fair of 1939 by the Edward G. Budd Manufacturing Company.[20] Since that time they have been extensively used.[21] Another installation is shown in Figure 17.

The new "Empire State Express" which the New York Central placed in service in December 1941 is almost entirely lighted by these lamps so far as the bodies of the cars are concerned. One of the coaches is shown in Figure 18.

The lamps are mounted in fixtures beneath the baggage racks transversely of the car.

The 9- by $^5/_8$-inch (T-5) fluorescent lamp is also suitable for d-c operation at 60 volts. The connections used are as shown in Figure 16, but an auxiliary and ballast lamp suitable for a lower current are used. So far there have been no actual d-c applications of these lamps, but they have been used in some a-c installations.

Investigations made so far offer very little encouragement for the d-c operation of fluorescent lamps at 30–32 volts. In order to operate at this low voltage the length has to be reduced so much that the lamps are not efficient. Therefore in order to provide fluorescent lighting on such cars, either inversion must be made to alternating current or a booster used (Figure 19).

The booster is relatively efficient because about half the power comes directly from the battery. By boosting to 65 volts, 18- by $1^1/_2$-inch (T-12) lamps can be used; or by boosting only to 60 volts, 15- by $1^1/_2$-inch (T-12) lamps can be used.[22] One or two installations of these boosters will be made soon.

Recently there has been developed a voltage doubler using a vibrator for this same purpose, which may prove to be more efficient even than the booster.

The Norfolk and Western Railway has experimented

**Figure 18 (above). Fluorescent-lighted coach, "Empire State Express"**

**Figure 17 (left). Fluorescent-lighted observation car, "Pacemaker"**

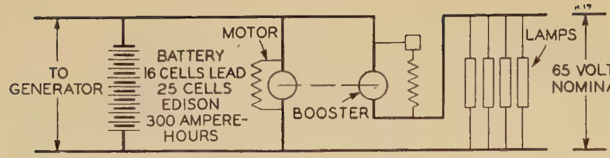



**Figure 19. Schematic diagram showing connections of booster for operation of fluorescent lamps from 32–40-volt d-c source**

*Booster is inherently regulated to maintain approximately 65 volts at lamps*

widely with various types of fluorescent lighting, including operation of conventional types of fluorescent lamps in series using cold-cathode starting (Figure 20), and also with the use of neon tubes.[7] The operating results of these applications will be awaited with interest.

Many applications of fluorescent lamps have been made on other railroads along the lines of conventional a-c operation at 115 or 230 volts, with a number of d-c applications included among the more recent ones. Where a-c power is already available, either from the head-end system used on a number of streamlined trains or from an individual engine-driven power system, the operation of fluorescent lamps directly from alternating current is, of course, much simpler, as no inversion means is required.

## POSSIBILITIES OF THE FUTURE

It takes a brave man to predict the future nowadays, but nevertheless it is interesting to speculate on possible future developments. These I believe will consist of:

1. Further improvement in the present hot-cathode tubular lamps to lengthen life, reduce blackening, and so on.

2. Improved auxiliary and power conversion equipment.

3. Development of shorter tubes for use in passageways and for special lighting problems.

4. Further development of means for operating lamps from direct current at 32 volts, including possibly direct operation at this voltage.

5. Development of globular-type lamps, particularly for the smaller sizes. This has already been done in the cold-cathode type.

Remarkable as the present fluorescent lamps are, they still do not equal in efficiency the light from the firefly or from phosphorescence, and until this secret is solved we will have a great deal to look forward to. Possibly in another 20 years the present fluorescent lamps will be as passé as the Pintsch gas lamps of Figure 1 are today.

In writing this article the author has traced the development of modern car lighting in recent years as carried out by the New York Central System with which he is connected. Other railroads have progressed along similar lines and their contributions to the art are fully recognized, but to describe all the types of installations that have been made would require a book, not an article. It is hoped that the examples given herein will serve to illustrate the progress that has been made and stimulate readers to investigate the installations more fully for themselves. Practically all the new installations have been fully described in either the *Railway Age* or the *Railway Electrical Engineer*.

Coaches have been discussed for the most part in this article. They constitute the majority of the railroad-owned passenger-carrying rolling stock. On account of the number of cars of this type involved it is necessary that any improvements made be at the minimum cost. Also the levels of illumination provided in such cars previous to 1935 were in general considerably below that of dining and other special types of cars. Furthermore, the lighting of cars other than coaches is often influenced to a much greater extent by the desire to apply architectural and decorative treatment in connection with the lighting than is the case with coaches.

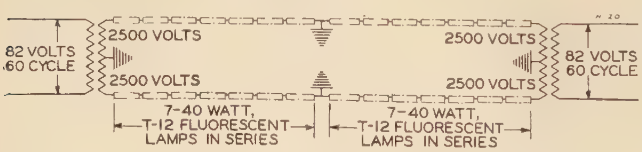



**Figure 20. Schematic diagram for operation of conventional fluorescent lamps in series using cold-cathode starting**

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# Ten Years of Progress in Lightning Protection

This is the third and last of a series of related articles reviewing the progress made in the past decade in the protection of electric power-system circuits and equipment. This article, which like its predecessors was prepared under the auspices of the AIEE committee on protective devices, is concerned with the protection of systems against lightning, lightning-surge protective devices, and limitation of fault current. The two previous articles of the series, which appeared in November and December 1941 issues, respectively, of "Electrical Engineering," dealt with circuit-interrupting devices and with protective relaying.

THE EARLY HISTORY of installation and operation of electric-power systems indicates that serious troubles were experienced in line outages and apparatus failures caused by lightning. Manufacturers and operators quickly discovered that special protective devices were necessary to drain lightning currents from the system, and thus prevent dangerously high surge voltages.

During the early years of application of these devices, it was learned that arresters must be applied adjacent to the specific apparatus requiring protection, and some knowledge was gained regarding the traveling-wave aspects of lightning surges on systems. By 1930, enough had been learned about the nature of lightning, particularly from cathode-ray oscillograph studies in the field, and about design and construction of lightning arresters and their proper application, to eliminate a considerable percentage of the early difficulties. At that date, valve-type arresters were in general use for protective purposes. These devices could not always be constructed with sufficient protective ability to take care of the older and weaker transformers, or of rotating machinery. They also were sometimes destroyed by unusually heavy lightning discharges, and suffered from some mechanical defects. Nevertheless, the whole state of the art was in such a stage that growth of electric systems was not inhibited by lightning problems. Progress of art in the decade 1930–40 has been directed, therefore, toward a more exact determination of the nature and frequency of lightning strokes, and a more scientific design and application of insulation and protective devices to prevent line interruptions or equipment damage by lightning.

Lightning studies have been considerably facilitated by improvement of the cathode-ray oscillograph and by development of new instruments for recording lightning- or test-surge currents. Recent improvements of the cathode-ray oscillograph permit higher writing speeds, greater ease of obtaining pictures, and closer synchronizing of oscillograph initiation with the event to be recorded.[1,2] For recording characteristics of lightning currents, several new instruments, which require a minimum of supervision have been developed. Some of these are low enough in cost to permit their installation in large numbers covering extensive areas. Notable among these devices are the paper-insulated-gap surge recorder,[3] the magnetic-link surge recorder,[4] the magnetic surge-front recorder, the magnetic surge integrator, and the fulchronograph.[5]

### FIELD STUDIES

Since the development of these recorders, a large body of lightning-current data has been collected by various investigators throughout the United States. These data indicate that lightning-stroke currents may be as high as 200,000 amperes, giving rise to currents through a single transmission-line tower as large as 150,000 amperes. Expectancy curves have been obtained from these data showing the probable magnitude of lightning-stroke currents, or the lightning currents that may flow through a transmission-line tower.[6,7] Records also have been made of lightning-discharge currents through arresters which were estimated as high as 40,000 amperes for distribution-type arresters and 19,000 amperes for station-type arresters. Expectancy curves have been obtained from these records, showing the discharge currents that may be expected to flow through distribution arresters[8], or through station arresters.[9] Additional data are now being collected on the duration and wave shape of lightning currents in direct strokes and arrester discharges. Although these records have not yet been accumulated in large volume, there are indications of the influence of system characteristics and geological conditions on the nature of the discharge through lightning arresters.[8,10]

Using the Boys and other high-speed cameras, and the crater-lamp oscillograph,[11] a number of records were

obtained of lightning strokes to high and medium-height structures. These records disclosed the mechanism of the lightning discharge, showing that it is initiated by a streamer or "leader stroke," followed by the main discharge or "return stroke," which consists of one or more high-current discharges of durations less than 100 microseconds, and low-amperage discharges lasting several thousand microseconds. The majority of strokes recorded were the "multiple" type, consisting of more than one high-current discharge. Many "continuing strokes" were also recorded, made up of long-duration discharges with or without superimposed high-current peaks. In many cases the amount of charge released by a complete stroke was much greater than had heretofore been anticipated, and high rates of current rise occurred on the fronts of some high-current discharges.[12,13]

On the basis of these field measurements of lightning, impulse generators recently have been designed to deliver high-current short-duration and low-current long-duration surges for test purposes, which simulate actual lightning.[14,15] These now make it possible to test apparatus and protective devices with surges such as may be encountered in service.

### LIGHTNING-SURGE PROTECTIVE DEVICES

The increased knowledge of the nature of lightning and the development of improved impulse-testing technique have resulted in much improvement in the design of the conventional valve-type arresters.[16,17,18] These improvements have been along two major lines: (*a*) providing a lower protected level and (*b*) increasing the reliability of the arrester itself, particularly in regard to discharging lightning currents greater in both magnitude and duration.[19] The lower protected level has been obtained on short-time impulse stress by improvements in the design of the multiple series gap, and the long-time characteristics have been improved by changes in the valve element which produce a lower *IR* drop, particularly on the higher values of current. This lower protected level affords a greater margin of safety for present equipment and on new equipment produces a real saving in the requirement of a lower impulse strength.

Improvements in the reliability of the conventional lightning arresters have been concerned with electrical and mechanical characteristics. Since the system-dynamic-overvoltage characteristic of lightning arresters is considered as the basis of rating, electrical failures from that cause have not been reduced; the failures from impulse-current discharge have been reduced by changes in design of the valve element. The principal improvement in mechanical reliability is the use of better sealing against the entrance of moisture.

The past decade has also brought other improvements in lightning arresters. Some worthy of note are greater uniformity both in the product of a single manufacturer and among manufacturers, and the extension of the unit type of design to line-type as well as station-type arresters. This has proved helpful in the application and testing of lightning arresters, and also reduces the number of replacement units required in stock.

In order to facilitate arrester application the AIEE lightning-arrester subcommittee undertook several years ago to establish "industry values" of arrester performance on a uniform basis. Tabulations of these values have been reported by the committee and published by the Institute.[20,21,22] These data make it possible to coordinate arresters with the insulation of equipment to be protected, and to estimate margins of protection available which indicate the limiting distances from apparatus to be protected at which arresters may be located.

For many years, sphere or rod gaps have been used on electric systems as relief points for lightning voltages. As a result of the considerable experimental work done in the past decade, it was learned that the inherent time-lag of the rod gap limits its usefulness except for protection of porcelain insulators and other line-type insulation. A recent improvement in the rod gap[23] has reduced its time-lag by the addition of flux controls so that it now may be used to protect transformers and other outdoor-station apparatus.

The ordinary rod gap is still handicapped, however, by its inability to clear power-frequency current which may follow the lightning discharge. The gap thus may be the cause of frequent line interruptions. To overcome this difficulty, a modified gap called a "protector tube" recently was developed,[24,25] which is capable of interrupting any power-frequency current within its rating that may discharge through it. This tube recovers within a cycle or two and is then ready for the next surge.

### LIGHTNING-ARRESTER STANDARDS

As the general fund of knowledge concerning lightning phenomena increased, it became possible to set up requirements for performance of lightning protective devices. The AIEE lightning arrester subcommittee undertook this task and reported a lightning-arrester standard which was adopted in 1936 by the AIEE and the American Standards Association. This standard is now being revised. The principal changes being considered are in the specified tests and the testing technique.

The lightning arrester subcommittee also reported a proposed standard for protector tubes, which was published July 1940 for one year's trial use. Inasmuch as this standard exempted the special type of tubes designed for distribution-transformer protection, an additional standard for these devices is now being worked out.

### INSULATION LEVELS

A greater body of impulse-flashover data has been collected in the last ten years by various laboratories throughout the United States. To facilitate agreement on such data, which inherently has a wide spread, a subcommittee on correlation of laboratory data was

formed by the Edison Electric Institute and the National Electrical Manufacturers Association. This subcommittee adopted tabulated values of impulse-flashover for sphere and rod gaps,[26] and set up a more or less standard technique for impulse testing.[27] Impulse-flashover data are now available for line insulators and for wood,[28] so that these materials may be combined efficiently as line insulation against lightning with reasonable certainty of satisfactory performance.[29]

A limited amount of impulse-breakdown data has been obtained for sphere and rod gaps in oil.[30] Transformer-type insulations and solid insulations, such as are used in electric cables, also have been tested with impulse voltage for breakdown.[31,32,33,34] These latter insulations display much less time-lag to breakdown than do rod gaps in oil or air, or porcelain insulators flashing over in air. It was also learned that repeated applications of a voltage 20 to 25 per cent less than the one-shot breakdown value may cause failure, which indicated that in some cases each application of the reduced voltage damaged the solid insulation in a manner that was cumulative.

Another factor which contributes a great deal toward a more exact application of insulation in design is the recent agreement on basic impulse insulation levels.[35] These levels are based on the protective levels afforded in the various voltage classes by available lightning protective devices. They provide for each voltage class of apparatus a specific minimum insulation strength which the design engineer must meet and upon which the operating engineer can depend. They also provide the operating engineer with a desirable basis for better correlation of his older and newer equipment. By test he now may classify his old equipment and protect it adequately with modern devices which have more definite classification and more predictable performance than the earlier devices.

## APPLICATION PRACTICES

These additions to our knowledge of lightning and performance of insulation and lightning-protective devices in the past ten years have been the basis for many improvements in established methods of lighting protection, and have stimulated development of new schemes for protecting lines and apparatus. The use of ground wires above transmission lines to protect them from lightning has been practiced for some time, but in recent years, such applications have been based on wider information. Engineering methods are available for determining the various factors—such as optimum location of overhead ground wires,[36,37] permissible tower-footing resistances, and the necessary line insulation levels at tower and midspan—which must be considered in the design of a transmission line that can be expected to have the desired immunity from tripout caused by direct strokes.[38] Where tower-footing resistances are high and cannot be reduced satisfactorily by driving ground rods, nearly equivalent results may be obtained in many cases by the use of "counterpoises" which are lengths of wire connected to the tower legs and buried a few feet in the ground.[39] Usually from one to four 50-foot lengths at each tower will suffice, but under exceptional conditions it may be necessary to bury a continuous wire under the transmission line, connecting it to each tower footing.[40]

Greater appreciation of the insulating value of wood for impulse voltages has resulted in extensive use of wood for line insulation against lightning, supplementing the porcelain insulation necessary for power-frequency voltage.[41] Thus, pole and crossarm wood was used to provide greater impulse-voltage insulation between conductors, and from conductors to ground.[42,43] Whereas transmission lines above 66 kv originally were strung from steel towers, it is now not unusual to use wood structures for lines up to 132 kv, inclusive.

Experience has clearly demonstrated, however, that it is impossible to insulate a line against severe direct strokes to the phase conductors. Some means must be provided to drain the lightning current from line wires if tripouts and possible equipment damage are to be prevented. Protector tubes have been used widely for this purpose, with both steel-tower and wood-pole lines.[44,45] The degree of protection provided by the tubes depends on wire clearances, span lengths, and the ground resistances encountered. Where resistances are quite low and span lengths short, it may not be necessary to install tubes at each structure. Engineering data necessary for proper application of the protector tubes is now adequate,[24,46] and many successful installations have been made. An unusually economical application of protector tubes recently worked out for wood-pole lines, has one phase wire raised above the other two so as to shield them from direct strokes. Protector tubes are then installed on this shielding phase at proper intervals to drain lightning currents from it.[47] Added precautions must be exercised to provide sufficient wire clearances, and to provide adequate impulse insulation at each pole by taking advantage of the wood insulation of pole and crossarms.

Another solution of the problem of line protection is to accept the lightning flashover, but to interrupt the power arc by high-speed switching before serious damage can be done, and then restore the line by high-speed reclosing of the breakers. This has been accomplished with three-pole breakers and more recently by single-pole breakers, which limit the disturbance on the system to as little as 20 cycles from the instant of power arcover to the instant of line reclosure.[48,49] Such rapid fault clearance and reclosure minimizes shock to the system and prevents loss of load during the interruption.

A somewhat similar scheme has been worked out for distribution lines to prevent wire burndown resulting from transient faults such as lightning flashovers.[50] A high-speed contactor short-circuits the line voltage, thus extinguishing the arc. A high-speed breaker then inter-

rupts current through the short-circuiting contactor, restoring normal potential to the line and allowing the short-circuiting device to drop out. After a predetermined time interval the interrupter recloses and the device is ready for another operation. The total time of the disturbance from the instant of arcover to restoration of voltage is subject to control and may be as short as six cycles.

A few outstanding improvements in apparatus protection also have been made during the past decade. A proposal to improve distribution transformer protection by interconnection of the lightning-arrester ground lead and secondary neutral at the transformer had been considered for some time before 1930, but its acceptance was postponed because of doubt as to the effect of the lightning currents on the secondaries. Exhaustive tests made in 1931 demonstrated the safety and effectiveness of this scheme[51–56] and acceptance has since become quite general. This grounding scheme eliminates the effect of arrester ground resistance, and insures that the lightning voltage impressed on the transformer windings will be approximately equal to the arrester discharge voltage, which is a predictable quantity and is well coordinated with the transformer insulation.[57]

Insulation failures of rotating machinery (also induction regulators) caused by lightning were found in many cases to be interturn failures, or failures near the neutral of wye-connected windings. Tests showed that a steep-front voltage wave would cause high interturn stresses, and, if entering on two or more phases would cause a reflection at the neutral which might result in double voltage at that point. Lightning arresters alone were only partially effective because they did not moderate the voltage-wave front. The most effective protection was found to be a set of arresters on the line with an interposed surge impedance of about 1,000 feet of line, or a lumped inductance, such as a feeder reactor, between these arresters and the machine. A set of capacitors of 0.25- to 0.50-microfarad capacitance on each phase at the machine with possibly a set of arresters connected in parallel, completes the protection.[58] The line arresters limit the crest value of the incoming surge; the interposed surge impedance limits the current magnitude, which determines the charging rate of the capacitors, which in turn, determines the wave front of

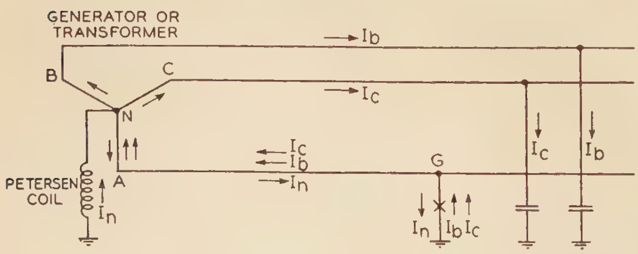


**Figure 1. Three-phase system with Petersen coil between neutral and ground, showing flow of current with arc from conductor A to ground**

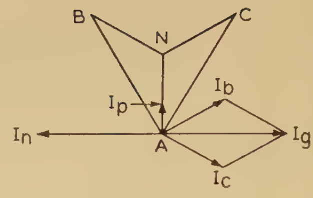


**Figure 2. Vector diagram showing relation of charging current and Petersen-coil current with fault on conductor A at point G (Figure 1)**

*$I_b$—charging current from conductor B to ground*

*$I_c$—charging current from conductor C to ground*

*$I_g$—total charging current $(I_b+I_c)$*

*$I_n$—Petersen-coil current*

*$I_p$—in-phase current resulting from corona, line loss, etc.*

*NA, NB, NC—line-to-neutral voltages*

the voltage impressed on the machine. In this manner, wave fronts can be sloped off so as to prevent high interturn stresses and reflections at the winding neutral.

## FAULT-CURRENT LIMITING DEVICES

Another method of preventing line interruptions caused by transitory faults such as lightning flashover is the ground-fault neutralizer known as the Petersen coil.

These devices, variously known as resonant neutral-grounding reactors and as ground-fault neutralizers, were first used in Europe a number of years ago, and a few installations were made in America over ten years ago. In the past decade, however, tests[59,60] and operating experience[61] have put this method of protection on a more predictable basis,[62] and many new installations have been made in the United States.

The theory of operation of the Petersen coil may be briefly explained as follows: A transmission or distribution system of large extent possesses an appreciable capacitance between conductors and ground and, when one conductor of an otherwise ungrounded system becomes faulted to ground, an appreciable current will flow to ground through the fault and back through the capacitance between ground and the remaining conductors. If the system neutral is connected to ground through one or more reactors, the reactor current will also flow through the fault (Figure 1). By proper choice of neutral reactances, the charging current and the reactor current in the fault may be made numerically equal, and they will be almost opposite in phase (Figure 2). Thus, the resultant of these two components of the fault current becomes very small, and the arc is extinguished. When the neutral reactors are selected to produce this condition they have commonly been called Petersen coils.

In practice, on typical resonant-grounded systems, it has been found that from 60 to 80 per cent of all faults are self-extinguishing, without the necessity for circuit-breaker operation. The remainder include those involving two or three phases, where the Petersen coil has no effect on the fault current flowing in the short circuit between phases, and those faults to ground which are permanent and therefore cannot be removed by the

Petersen coil. For such faults circuit-breaker operation is required to isolate the defective section of the system.

In comparing low-impedance grounding and resonant grounding a number of factors must be considered. With resonant grounding, the unfaulted phases are subjected to line-to-line voltage to ground, while with low-impedance grounding the voltage to ground may be less or greater than line-to-line voltage, depending upon the ratio of $X_0$ to $X_1$.

Since system insulation is selected on the basis of overvoltages caused by lightning, such insulation—except possibly the insulation at transformer neutrals—is not affected by the presence or absence of Petersen coils. Ungrounded neutral lightning arresters must be used with Petersen coils, also with low-impedance grounding unless the ratio of $X_0/X_1$ is less than about 3. Selective relaying of permanent ground faults on Petersen-coil systems with radial lines may be accomplished by automatically short-circuiting the coil, which permits the ground relays to function and to isolate the faulty line section.

*Standards for Neutral-Grounding Devices.* A comprehensive standard covering neutral grounding devices has been in the process of preparation by the AIEE fault-current limiting devices subcommittee for some time and will soon be issued. This standard applies to grounding impedances, resistors, reactors, capacitors, and combinations of these when used for grounding the neutrals of a-c systems.

*Grounding Practices.* A review of present-day practices in the grounding of transmission systems is being made by a joint committee of the Institute. This work is being conducted along lines similar to those followed in the study made in 1931.

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# Wartime Electric-System Planning

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**Policies and procedures to assure adequate power supply to our mushrooming war-production industry have been discussed in a series of articles in the January issue (pages 3–30) and in a group of technical papers published in the March issue (Transactions pages 105–26). Supplementing those articles and papers, this article outlines the wartime planning procedures of a large eastern power company that has been called upon to serve many war-production plants scattered over its entire system, at the same time conserving critical materials. The rapid transition from a peace to a war economy precludes the formulation of settled policies, say the authors.**

THE YEAR 1941 brought New Jersey defense contracts of more than two billion dollars and with them new highs of electric-power consumption and new problems in electricity supply. Among the larger industrial concerns that have felt the impact of what was the defense program and is now the victory program may be mentioned the Wright Aeronautical Corporation, Otis Elevator Company, Bendix Aviation Company, the Federal and New York Shipbuilding companies, Crucible Steel Company, RCA Manufacturing Company, John A. Roebling's Sons Company. One estimator has said that the state is doing more than 10 per cent of the total defense–war job.

The load of the Public Service Electric and Gas Company, which in the five years ending in 1938 was growing at the rate of 30,000 kw a year, has increased in the last three years at the rate of 80,000 kw a year. In the fall of 1939, shortly after the system began to feel the effects of the defense and the British supply programs, the 1941 peak load was estimated at 850,000 kw, and plans were begun to meet this load. The peak load actually experienced in 1941 was 871,000 kw.

In normal times, system planners estimate and analyze loads, establish policy in regard to the amount of spare capacity and equipment required to maintain desired service standards, conceive and study schemes, and assemble results. But in wartime the emphasis shifts radically. The fact that the United States is engaged in mortal combat, requiring the straining of every resource of our industrial system to the limit of its capacity, calls for, and is getting, a complete reorientation of plans, policies, and objectives in all walks of life—by utility planning engineers as well as industrialists and others. Our sole aim now is to win the war. The rapid transition from a peace to a war economy which is taking place precludes the formulation of settled policies. Indeed, it is essential that our thinking, as well as our power systems,

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be flexible and adaptable. A workable formula today is obsolete tomorrow.

The most important element of the present load situation as it appears in the territory of Public Service Electric and Gas Company is the extreme spottiness of the growth pattern. Whereas heretofore growth in various areas has borne a fairly uniform relationship to growth in the system as a whole, now in certain regions loads have jumped ahead by leaps and bounds, while in others scarcely the normal trend of growth has been achieved. Obviously, there can be no such thing as co-ordinated, long-range planning in detail for this type of unanticipated growth.

The company's regular practice has been to make a load estimate in February and to review this in October, occasionally making some changes. During the past year, however, we have reviewed our estimates more or less completely four times. The objective under present conditions is to have estimates for detailed parts of the system which are fairly good for possibly 18 months in advance. The former practice was to carry many estimates ten years into the future.

In 1938 the Public Service company peak load was 632,000 kw. In 1941, it was 871,000 kw, a growth of 239,000 kw in three years, or about 12 per cent per year. This is not extraordinary, but it is a phenomenon not experienced since 1929 and the three-year increment itself exceeds the total system demand of any year prior to 1922. At the same time our system annual load factor has increased from an average of about 51.2 per cent, obtaining from 1930 to 1940, to 53.7 per cent for 1941. Industrial kilowatt-hour sales are up 31 per cent over 1940 and 79 per cent over 1938. Industrial building contracts in New Jersey are up 94 per cent over 1940, residential 21 per cent.

These increased demands have been met by investing some $30,000,000 in the plant since 1938—an investment cost of about $125 per kilowatt for generation, transmission, substation, and distribution equipment combined. This compares with an over-all investment in 1923 at the rate of $220 per kilowatt and with an incremental investment per increment of load from 1923 to 1929 of over $500 per kw. Although the latter figure included change from two-phase to three-phase operation of distribution lines, and major steps in a low-voltage network program as well as in the construction of bulk power facilities, it is still evident that in recent years expansion policies have been very conservative. This is pertinent to the present discussion because we believe that one of the major objectives of a planning organization should be to discover means of carrying increasing loads at decreasing cost per kilowatt by reducing the system "overbuild," reducing the spare capacity and equipment required, and in other ways securing more effective use of equipment. This must be and in the present case has been achieved without impairment of service standards. Total kilovolt-ampere-hours of interruption to all customers from all causes on the Public Service system in 1941 were below the average for the previous six-year period.

To show how this better use of investment dollars has been obtained, we are reviewing the company's spare-equipment policy and methods of rating lines and apparatus. We shall also speculate a little as to future trends.

### LIMITING SPARE CAPACITY AND EQUIPMENT

The Public Service company's orthodox policy is that there must always be at least one spare unit for every link in the chain of electricity supply from the coal pile to the substation low-voltage bus, or in dense load areas, to the customers' service from a secondary network, and that for elements where outages of several weeks are to be anticipated, two spare units may be justified. Without modifying this policy, one trend of our system-planning effort in recent years has been to make one spare unit serve increasingly large portions of the system. For example, instead of having a complete spare transformer bank in each switching station, we have worked out means of retaining local 26-kv ties between load areas so that spare capacity in one switching station may be made more or less completely available in another. A new switching station is being built near Elizabeth, N. J., which initially will be a nonfirm source, having only one transformer bank installed. This installation will be about midway between two other bulk power sources and will be linked to both by 26-kv lines. As loads increase, instead of having full spare-transformer capacity at three locations, it will be necessary to maintain in the entire combined area only perhaps one half that amount.

In the Camden, N. J., area, which is heavily occupied with war construction, we have met 9 years' growth in 3 years. Location of a switching station in this area had been contemplated for 15 years or more, but had been postponed by dependence on 12-mile 26-kv transmission lines and a local interconnection. The first unit in the switching station went in service in 1940 as a single 132-kv transmission line, a single transformer bank, and a 26-kv bus. The transmission and interconnection continue to provide back-up supply and the entire switching station is considered a nonfirm source. The second unit, a second 132-kv line and transformer bank, with considerable reinforcement of local transmission but still with no 132-kv bus or breakers, is made necessary largely by absence of readily available back-up supply over the low-voltage interconnection; it will go into service in 1942. Instead of segregating the area and serving it from the beginning as an isolated system with its own firm bulk power source, as would probably have been done in the 1920 era, this plan retains permanently the local 26-kv transmission as back-up supply, thus effecting a major saving of investment otherwise required for transformer capacity and additional equipment.

Projects handled in this manner are known as "program" construction jobs. They effect permanent reduction in spare apparatus, reduce greatly the inherent "overbuild" existing in the system at any time, and spread over a number of years major investments which otherwise might be difficult to justify economically.

Incidentally, the policy of retaining low-voltage ties between bulk supply points is highly advantageous as a safety measure in wartime, with the ever-present, even if remote, threat of bombing attacks or sabotage that might render a single switching station useless for an extended period of time.

## INCREASING RATINGS

Another method of reducing investment in spare equipment is to increase acceptable loadings. There are two steps in this process. The first is the orthodox procedure of installing special cooling equipment, such as fans on transformer banks, to permit higher loadings, usually only required under emergency conditions. The second is, in addition to installing cooling equipment, to accept higher temperatures during such emergencies in recognition of the fact that these are very infrequent and that any resulting decrease in life of facilities is probably justified many times over by the savings effected. Both of these measures have been applied very widely in the Public Service system.

Fans for forced air cooling of transformers, although not always included in the initial installation, are invariably considered in the expansion program. In the rating schedule there is also an emergency short-time allowance based on the heat-absorptive capacity of the unit and the loading in effect prior to the emergency. A typical transformer-rating table shows that a transformer bank, nominally rated 55,500-kva, oil-immersed self-cooled, 40 degrees centigrade ambient operation, may be used to carry normal peaks of as much as 92,000 kva, with forced air-cooling at 10 degrees centigrade ambient, on the Public Service company load cycle, and even more than that for brief emergencies.

In spite of these measures to increase the effective use of equipment, we all know that higher loads will have to be carried, and quite probably without the new facilities we should like. We are planning for this too, because it appears to us that by forethought added loads may be taken, perhaps with a somewhat experimental attitude toward the service that will result, but at least in a rational and economically balanced manner.

## FLEXIBILITY IN USE OF SPARE EQUIPMENT

At important locations where large tranformer banks are used, many companies probably have provided, as ours has, a complete spare bank and also a spare single-phase unit. This policy is based on the assumption that one fault requiring several weeks for repairs may overlap in time with another fault. The first fault would be repaired by utilizing the spare unit. Another fault thereafter would make one bank indefinitely unavailable. Thus provision is made for two major faults. A probability study of transformer outages shows that for stations having a spare unit and also a spare bank the service interruptions resulting from forced unavailability of transformer capacity should be on the order of only a few minutes per million hours of operation. If there is no spare unit, this figure rises to possibly two or three hours per million hours of operation. This study was made some years ago and the basic assumptions as well as the conclusions have been confirmed by the almost complete absence of serious trouble on these banks.

From the service standpoint, using the spare unit as part of the next bank when required by load growth, instead of maintaining it as idle spare equipment, undoubtedly would result in some impairment of present standards, because of the reduced facilities for carrying out maintenance work and because of the rare double fault conditions. However, from an economic standpoint, the results are entirely favorable, since there would be no increase in the average loading on the remaining transformers and hence no change in the service-life expectancy of the equipment. As an intermediate course, if elimination of the spare units appears an unnecessary hazard to service, it may be desirable to retain one or two spare units available for several locations, so that a unit could be moved to any place where it was needed within a short time.

In the smaller sizes of transformers as used in substations, three-phase units are standard practice and there is always one complete spare bank. In order to make more effective use of these units, the Public Service has increased their ratings by use of fans, by studies of daily load curves, by an allowance for the low probability of a fault being coincident with a peak demand, by increasing the permissible hot-spot temperatures, and by detailed studies of test data from heat runs at time of purchase. A transformer, nominally rated 4,000-kva, oil-immersed self-cooled, at 40 degrees centigrade ambient, for which, incidentally, we find it worthwhile to pay a special bonus for low losses, may thus have an emergency rating of 10,000 kva. Still our outage rate per bank on three-phase substation transformers for all causes is only about once in 25 years. One possible means of avoiding new investment in this class of equipment is to purchase a portable spare transformer, especially designed for highway transportation, and then increase emergency ratings still further because of the reduced likelihood of long dependence on them.

## INCREASED LOADING POSSIBILITIES

The effective loading of all transformers also might be increased by relying in an emergency upon cooling by means of water sprays on the transformer radiators in conjunction with the forced air. This procedure would result in substantial increases in temperature gradients

within the units, and terminal boards, connections, and so forth, might become dangerously overheated. Careful investigations of transformer design therefore would have to be made before such a plan could be adopted, but it is definitely a possibility for study.

In large transformers the maximum hot-spot temperature permitted is 105 degrees centigrade; in smaller units 115 degrees centigrade is accepted. Perhaps, in view of the excellent record of this apparatus in service, we might go higher. In the last 20 years the Public Service Electric and Gas Company has had no known case of a station transformer failure caused by overload (though there have been some troubles with contacts in tap changers), nor has it any case on record of a large air-cooled transformer actually having been loaded to its full allowable rating. Probably in most other systems the same is true. Of course, should such a load occur on a transformer, we would not be bound by a calculated rating but would allow it to take load on the basis of actually observed temperatures.

In the turbine room, recognizing the fact that there is some elasticity in the ratings of turbines in a large system, we have run a series of tests on individual machines to determine their actual "proved overload" capacities. While the capacities thus found are not simultaneously available on all machines in one station because of boiler and other limitations, the results do indicate that for short periods rather substantial amounts of capacity may be available, over and above normal ratings.

Perhaps the best means of obtaining increased output from generators on many systems, assuming the turbines and boilers are adequate, is to raise the power factor of the load by installing reactive capacity, thus enabling greater kilowatt load to be carried with the same kilovolt-amperes on the machine. The Public Service company has done this by the very extensive installation of static capacitors and expects to go further with the program in 1942 and 1943, using both static capacitors and synchronous condensers. Upon completion of the work now authorized we shall have added 134,000 kva (742 banks at name-plate rating) in static capacitors on distribution feeders and 107,500 kva in synchronous condensers. Up to certain limits, static capacitors will provide needed reactive capacity at very low cost and with an almost negligible use of "bottle neck" manufacturing facilities. Installed on distribution feeders, these units also save needed transmission and transformer capacity and have many other advantages.

Many generators may be operated safely at slightly higher than present operating voltages. This will increase output and can readily be accomplished by connecting the machines to the system through autotransformers. In several cases we have found it worthwhile.

Generator ratings also may be increased by more effective use of cooling media. The pressure of the cooling gas may be raised (as has been done by Public Service) or other means employed.

In the 13- and 26-kv subtransmission system the simplest type of network consists of straight radial feeders from the source to the substation, one feeder being spare over the anticipated annual peak load. Obviously, if another substation can be connected into this network in such a way that one spare feeder is adequate for both, a saving has been achieved. Following this policy, we now have very few radially fed single-substation networks. Ordinarily there is only one spare feeder in any network serving up to five or six substations.

The normal rating of each circuit indicates the daily peak which it may carry repeatedly without damage. Two figures are given, one applicable to summer and the other to winter. The temperature limitation is that established by the AIEE and due consideration is given to thermal conditions along the route of the line, number of cables in the duct runs, shape of daily load curves, and other factors.

For short periods considerable heat-absorptive capacity exists in a cable and duct system. Also, since in every network there is at least one full spare circuit, it follows that at the time of a fault no circuit in the network will have been operating up to its maximum allowable temperature. Therefore, immediately following a fault there is for a considerable period of time a justifiable emergency rating. A curve has been prepared which gives this emergency rating for any transmission circuit. If there are a small number of circuits in the network, the load prior to fault is a lower percentage of the normal rating than if there are a large number. The temporary allowance is therefore higher for small networks. The emergency is assumed to exist for not more than 24 hours and the ratings vary from 10 to 25 per cent above normal.

Public Service has a rather high failure rate on its transmission cables. However, temperature surveys so far have failed to locate any cable in the system which actually is operating at or near the AIEE copper-temperature limit and, furthermore, economic studies indicate that the failure rate is still below the economic optimum.

## LIFE EXPECTANCY VERSUS LOAD

If average loading is increased, new investment is avoided; a consideration against that policy is the fact that a reduction in life expectancy is anticipated, which means increased maintenance costs and higher retirement charges. The most economical transmission system requires a balance between these two factors for minimum over-all annual cost. This is the approach which should be made to the problem of securing greater use of the subtransmission plant.

Recent studies show that for large transmission networks there is no economy in increasing the ratings because of the high average loading already obtained with the emergency capacities we now assign. However,

with small networks, increases up to 15 per cent in allowable ratings above the present normal appear to be good economy and a 20 per cent increase may not raise the total annual cost for transmission above that now obtaining. This is because for the smaller networks the percentage of spare capacity under our present policy is fairly large and the normal average loading therefore is low.

We are not suggesting that spare facilities be eliminated; the policy is that loads must be carried in spite of faults. A 10 to 15 per cent increase in ratings often will enable a system to carry new war loads and save investment, which, after the war is over, may prove to have been excellent economy. Our tentative—and we believe conservative—curve of life expectancy versus loading for 26-kv cable shows that even substantial increases in ratings of all circuits are not likely seriously to damage our transmission plant. Embarkation on such a program, however, must be gradual, so that retreat will be possible if service is too seriously harmed; it undoubtedly will be somewhat affected because of more frequent faults.

As a general comment on the matter of spare facilities under wartime conditions, there is much to be said for restricting the amount in actual service throughout the plant and holding this equipment in stock. Should a bomb hit a switching station, for example, it would disable active and spare equipment alike. In such an event, it would be much better to have the excess facilities stored in places other than the switching station itself. The same is true throughout the system. It is therefore our suggestion that, in accordance with the military formula, some of the reserves should be kept in the rear.

Our big problem today—the principal objective of every one of us—is to win a war. If we urge and secure priority for a single pound of steel or foot of copper which is less than absolutely essential for safety of service, if we push through a factory making war material—and almost all of them are—a single unnecessary piece of apparatus, we are evading responsibilities which Uncle Sam may fairly expect us to carry squarely on our own shoulders.

Now, if ever, national needs require that full use be made of every piece of apparatus, that spare facilities be cut to an irreducible minimum. If some impairment of service results, as it surely will, our public will readily understand. The voltage curve will not be so flat; occasional interruptions will occur; but our public will wholeheartedly approve. As a corollary, investment avoided during the war effort may have a very salutary influence on the financial statement after the fight has been won, since it can never appear in the form of unneeded plant on which to pay fixed charges. If we have presented an idea or two for increased use of plant, or saved the War Production Board the necessity of passing on a few priority applications, we will have done our mite toward victory and incidentally toward better economy in system planning.

# Radio Uses of Powdered-Iron Cores

THE use of finely divided particles of magnetic material pressed into shape and held together with a suitable bonding material has been employed for electrical purposes for at least half a century. The improvements in manufacturing technique, the lowering of costs, and the ability to produce materials having relatively high permeability and comparatively low losses, for frequencies even as high as 100 megacycles, have resulted in a substantial use of powdered core materials for communications circuits.

The practical uses of powdered ferromagnetic materials for use in communications circuits date back about ten years. The increased use of iron core material, especially within the past two or three years, gives every indication that iron-core inductors will continue to be of increasing importance in the communications field.

Powdered-iron cores are used widely in the manufacture of coils and tuning elements for broadcast and high-frequency receivers, but the use of such materials is not limited to such applications. With a favorable economic situation, the use of pressed cores might be extended to other uses as well. For example, audio-frequency transformers might be made with cores of powdered ferromagnetic materials rather than of laminated cores built up of thin stampings of iron. Furthermore, since core material can be pressed into complicated shapes which would otherwise be difficult to machine, powdered core material may be employed in communications or industrial circuits where magnetic paths of unusual or intricate shape may be required.

Already suitably prepared cores are finding application in tuning transmitters of relatively low power, that is, powers of 50 watts or less. The application of iron-core tuning methods to transmitters of power higher than about 50 watts depends upon overcoming the difficulty of dissipating the power loss within the core itself, and as materials with improved characteristics are developed, extensions of this application may be expected.

Modern iron cores are finding important applications in small loop antennas for directional-finding applications, especially on aircraft.

Other applications in which the ease of molding powdered iron into special forms may be utilized is in the manufacture of powdered-iron motor frames and armatures, special relay bobbins, audio and modulation transformers, etc. It appears probable that the processing of powdered-iron magnetic materials could be advantageously combined with the molding of plastics further to simplify communication and industrial electronic equipment of the future. The use of iron cores as electromagnetic shields is also a comparatively recent innovation in the communications field.

Excerpts from an article of the same title published in the February 1942 issue of *Electronics*, pages 35–7, 93–5.

# Laplacian Transform Analysis of Circuits With Linear Lumped Parameters

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**This article is the third in a series of five originally presented as lectures before the basic science group of the AIEE New York Section in a symposium on "Advanced Mathematics as Applied to Electrical Engineering." The first two are listed as the first two references at the end of this article.**

**The orderly and rigorous procedure of the Laplacian transformation is displacing Heaviside's direct operational calculus in the solution of linear differential equations with constant coefficients. It is applicable to equations having arbitrary initial conditions. The present lecture deals only with circuits having lumped parameters. The method is, however, valid for circuits having distributed parameters, as will be seen in the fifth article of the series. The reader who is not acquainted with integration in the complex plane should study the second article of this series before attempting the one which follows.**

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IN THE first article of this series[1] the direct operational method of Heaviside was discussed. In the second article[2] the theory of functions of a complex variable was considered. The results there obtained, in particular the theory of residues, are used in the present article to justify and extend Heaviside's method. The Laplacian transform is introduced, and the method shown by which, with its aid, the general circuit with lumped linear parameters subject to any given impressed voltages and arbitrary initial conditions may be solved in a straightforward systematic manner. The questions of the validity of many doubtful steps taken in the manipulation of Heaviside's operators do not arise in this method, since the Laplacian transform analysis makes no use of operators. The connection between the transform and the operational schemes is given, and many of the Heaviside formulas used in the first article are derived.

## THE LAPLACIAN TRANSFORM

The Laplacian transform of a function of time $f(t)$ is defined by the equation

$$\tilde{f}(p) \equiv \int_0^\infty f(t)\epsilon^{-pt}dt \tag{1}$$

where $p \equiv x+jy$ is any complex number subject to the one restriction that the real part of $p$ be greater than zero, $x>0$. The reason for this restriction appears later. It must be emphasized that $p$ is simply a complex number and must *not* be confused with the Heaviside operator $p=d/dt$ introduced in the first article of this series. The symbol $z$ is universal for the complex variable in mathematical treatises and was used as such in the second of these articles. The letter $p$ is here used in place of $z$, since electric circuits are under survey and electrical engineers have reserved the symbol $z$ for impedance. Equation 1 transforms a function of time $t$ into a function of the complex variable $p$. This is indicated by the wavy bar over the symbol representing the function under consideration. Thus, $\tilde{f}$ is read "the transform of $f$," "$f$ transformed," or simply "$f$ bar". The author has found this notation much more convenient than the other forms found in the literature.

The transforms of functions that appear most commonly in lumped-circuit analyses are derived here. In the next section these results are applied to the solutions of typical networks.

1. If $E$ is a constant, say a direct voltage, then

$$\tilde{E} = \frac{E}{p} \tag{2}$$

This follows directly from the definition of the transform as given in equation 1. Thus

$$\tilde{E} = \int_0^\infty E\epsilon^{-pt}dt = -\frac{E}{p}\epsilon^{-pt}\Big|_0^\infty = -\frac{E}{p}\epsilon^{-xt}\epsilon^{-jyt}\Big|_0^\infty = \frac{E}{p}$$

In substituting the upper limit in this equation, use was made of the restriction $x>0$, since this is necessary in order that

$$\lim_{t\to\infty} \epsilon^{-xt}=0$$

2. If $a$ is a complex number whose real part is equal to or greater than zero, then, according to equation 1

$$\left(\widetilde{\epsilon^{-at}}\right) = \int_0^\infty \epsilon^{-at}\epsilon^{-pt}dt = \frac{-\epsilon^{-(p+a)t}}{p+a}\Big|_0^\infty$$

$$\left(\widetilde{\epsilon^{-at}}\right) = \frac{1}{p+a} \tag{3}$$

3. The voltage across an inductance $L$ is $Ldi/dt$ where

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$i$ is the current in the circuit. Hence it is important to find the transform of $di/dt$.

According to equation 1

$$\widetilde{\left(\frac{di}{dt}\right)}=\int_0^\infty \frac{di}{dt}\epsilon^{-pt}dt=\int_{t=0}^\infty \epsilon^{-pt}di \qquad (4)$$

The well-known formula for integrating by parts is

$$\int udv=uv-\int vdu \qquad (5)$$

If $u=\epsilon^{-pt}$ and $dv=di$, then equation 4 becomes, with the aid of this formula

$$\widetilde{\left(\frac{di}{dt}\right)}=i\epsilon^{-pt}\Big|_{t=0}^{\infty}+p\int_0^\infty i\epsilon^{-pt}dt$$

The integral in this equation is, according to equation 1, simply the transform $\tilde{i}$ of the current $i$. Thus

$$\widetilde{\left(\frac{di}{dt}\right)}=-i_o+p\tilde{i} \qquad (6)$$

where $i_o$ is the initial value of the current, that is, the value of the current at the time $t=0$. Thus the transform of the derivative of the current has been found in terms of the initial value of the current and the transform of the current.

4. The voltage across a capacitor $C$ is $q/C$, where $q$ is the charge on the capacitor. Hence it is important to find the transform $\tilde{q}$ of $q$. According to equation 1

$$\tilde{q}=\int_0^\infty q\epsilon^{-pt}dt \qquad (7)$$

This is evaluated with the aid of equation 5. If $u=q$ and $dv=\epsilon^{-pt}dt$, then equation 7 becomes

$$\tilde{q}=-\frac{q}{p}\epsilon^{-pt}\Big|_{t=0}^{\infty}+\frac{1}{p}\int_{t=0}^\infty \epsilon^{-pt}dq$$

Since $dq=idt$, then the integral in this equation is, according to equation 1, simply the transform $\tilde{i}$ of the current $i$. Hence

$$\tilde{q}=\frac{q_0}{p}+\frac{\tilde{i}}{p} \qquad (8)$$

where $q_o$ is the initial charge on the capacitor, that is, the value of the charge at $t=0$. Thus the transform of the charge has been found in terms of the initial value of the charge and the transform of the current.

## CIRCUIT APPLICATIONS

1. Consider the circuit of Figure 1. There is a current $i_o$ in the inductance in the direction indicated on the diagram. The switch is closed at $t=0$. The current at any time thereafter is governed by the differential equation

$$L\frac{di}{dt}+Ri=E \qquad (9)$$

Multiply each term in this equation by $\epsilon^{-pt}dt$ and then integrate from 0 to $\infty$. In accordance with equation 1 this process is equivalent to taking the transform of each member of the equation. Thus

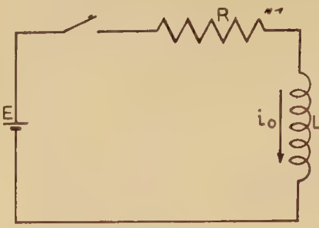


Figure 1

$$L\widetilde{\left(\frac{di}{dt}\right)}+R\tilde{i}=\tilde{E}$$

If equations 6 and 2 are used this reduces to

$$Lp\tilde{i}-Li_o+R\tilde{i}=E/p$$

or

$$\tilde{i}=\frac{E}{(p)(Lp+R)}+\frac{Li_o}{Lp+R} \qquad (10)$$

The differential equation for $i(t)$ has been transformed into an algebraic equation for $\tilde{i}(p)$. Furthermore, the proper initial condition has been introduced automatically. The desired solution of the network problem is the current $i$ as a function of time. In the next section is shown how this is obtained from the transform $\tilde{i}$ as a function of $p$. Several more examples which follow in this section show how $\tilde{i}(p)$ is obtained from the differential equations of the network.

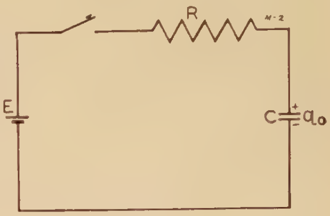


Figure 2

2. Consider the circuit of Figure 2. The charge on the capacitor is $q_o$ with the switch open. The polarity of the voltage is as indicated. The switch is closed at $t=0$. The voltage equation at any time thereafter is

$$Ri+\frac{q}{C}=E$$

The transform of this equation is

$$R\tilde{i}+\frac{\tilde{q}}{C}=\tilde{E}$$

If equations 8 and 2 are used, this reduces to

$$R\tilde{i}+\frac{\tilde{i}}{Cp}+\frac{q_0}{Cp}=\frac{E}{p}$$

Remembering that $q_o/C$ is the initial voltage $E_o$ on the capacitor, then

$$\tilde{i}=\frac{E-E_o}{Rp+\frac{1}{C}} \qquad (11)$$

3. Consider the network shown in Figure 3. If $i_1$ is the current in mesh 1 and $i_2$ is the current in mesh 2, the differential equations of the network are

$$\left.\begin{aligned}&0.1\frac{di_1}{dt}+30i_1-0.1\frac{di_2}{dt}-20i_2=30\\&-0.1\frac{di_1}{dt}-20i_1+0.1\frac{di_2}{dt}+25i_2+10^5q_2=0\end{aligned}\right\} \qquad (12)$$

The transforms of these equations are

$$\left.\begin{aligned}&(0.1p+30)\tilde{i}_1-(0.1p+20)\tilde{i}_2-0.1i_{1_0}+0.1\,i_{2_0}=\frac{30}{p}\\&-(0.1p+20)\tilde{i}_1+\left(0.1p+25+\frac{10^5}{p}\right)\tilde{i}_2+0.1i_{1_0}-0.1i_{2_0}+\\&\qquad 10^5\frac{q_{2_0}}{p}=0\end{aligned}\right\}\qquad(13)$$

where $i_{1_0}$ and $i_{2_0}$ are the currents in meshes 1 and 2 respectively at the instant *after* the switch is closed and $q_{2_0}$ is the charge on the capacitor at that instant.

Assume that the network is initially "at rest." This expression means that there is no current in any of the inductances and no charge on any of the capacitors in the circuit when the switch is open. Physically it is impossible for the charge on a capacitor to change instantaneously. Since $dq=idt$ a finite $dq$ in an infinitesimal $dt$ requires an infinite $i$, which of course can never be attained. Hence the charge on a capacitor the instant *after* closing a switch must be the same as the charge at the instant *before* the switch is closed. Similarly, since the voltage across an inductance is $Ldi/dt$, a finite $di$ in an infinitesimal $dt$ means an infinite voltage $Ldi/dt$, which is physically impossible. Hence the current in an inductance cannot change instantaneously. In other words, the current in an inductance the instant *after* a switch is closed must be the same as the current which existed in this inductance at the instant *before* the switch was closed. These considerations already have been used implicitly in examples 1 and 2 in this section.

These arguments dictate that $q_{2_0}=0$ and $i_{1_0}-i_{2_0}=0$, since the network was initially at rest. It must not be assumed that $i_{1_0}=0$ and $i_{2_0}=0$. The current in the inductance is $i_1-i_2$ and it is this quantity which does not change instantaneously. Thus, whereas $i_1$ is zero with the switch open, it is not zero at the instant after the switch is closed. A similar statement is true for $i_2$. It is shown later, however, that at the instant after the switch is closed $i_1=i_2$, so that $i_1-i_2$ does remain zero, as noted.

Substituting zero for $i_{1_0}-i_{2_0}$ and also for $q_{2_0}$ in equations 14 and solving for $i_1$ and $i_2$ yields

$$\left.\begin{aligned}\tilde{i}_1&=\frac{(30)(0.1p^2+25p+10^5)}{(p)(1.5p^2+10{,}350p+3\times10^6)}\\\tilde{i}_2&=\frac{(30)(0.1p+20)}{1.5p^2+10{,}350p+3\times10^6}\end{aligned}\right\}\qquad(14)$$

4. This example is an illustration taken from the first article in this series. A 1-henry inductance is in series with a 100-ohm resistance across a voltage of the form $\epsilon^{-100t}$. There is initially no current in the inductance. The differential equation of the circuit is

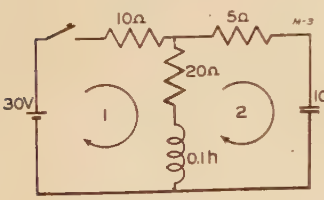

**Figure 3**

$$\frac{di}{dt}+100i=\epsilon^{-100t}$$

Taking the transform of this equation and making use of equations 6 and 3 yields

$$p\tilde{i}+100\tilde{i}=(\widetilde{\epsilon^{-100t}})=\frac{1}{p+100}$$

or

$$\tilde{i}=\frac{1}{(p+100)^2}\qquad(15)$$

INVERSE TRANSFORMS

The function of time $i(t)$ corresponding to $\tilde{i}(p)$ is called the inverse transform of $\tilde{i}(p)$. In order to complete the solutions of the networks discussed previously the inverse transform must be found. In each case considered $\tilde{i}(p)$ is of the form

$$\tilde{i}(p)=\frac{a_0+a_1p+a_2p^2+\ldots+a_np^n}{b_0+b_1p+b_2p^2+\ldots+b_mp^m}\qquad(16)$$

where $n$ and $m$ are finite integers with $m>n$ and where $a_0, a_1, \ldots a_n, b_0, b_1, \ldots b_m$ are constants.

It is shown in the appendix of this article that the inverse transform of an $\tilde{i}(p)$ of the form in equation 16 is

$$i(t)=\Sigma\,\mathrm{Res}\,[\tilde{i}(p)\epsilon^{pt}]\qquad(17)$$

where $\Sigma$ Res is read "the sum of the residues of."

In the second of these articles two theorems were given which allow the evaluation of residues with a minimum of labor. These are reproduced here for convenience, using the nomenclature of the present article.

*Theorem 1* (theorem 3, reference 2): Let $w(p)=f(p)/g(p)$, where $f(p)$ and $g(p)$ are regular at $p=p_o$ and $g(p_o)=0$, $g'(p_o)\neq0$, with $g'=dg/dp$. Then

$$\mathrm{Res}\left[\frac{f(p)}{g(p)}\right]_{p_o}=\frac{f(p_o)}{g'(p_o)}$$

The statement that $g'(p_o)\neq0$ means that $w(p)$ has a first-order pole at $p=p_o$.

*Theorem 2* (theorem 4, reference 2): If $w(p)$ has an $m$th order pole at $p=p_o$ then

$$\mathrm{Res}\,(w)_{p_o}=\lim_{p\to p_o}\left\{\frac{1}{(m-1)!}\,\frac{d^{m-1}}{dp^{m-1}}[(p-p_o)^m(w)]\right\}$$

In particular if $m=2$ (a second-order pole) then

$$\mathrm{Res}\,(w)_{p_o}=\lim_{p\to p_o}\left[\frac{d}{dp}(p-p_o)^2(w)\right]$$

This theory now is applied to complete the analyses of the previous section. The transform of example 1 (see equation 10) is

$$\tilde{i}(p)=\frac{E}{(p)(Lp+R)}+\frac{Li_o}{Lp+R}$$

Hence

$$i(t)=\Sigma\,\mathrm{Res}\left[\frac{E\epsilon^{pt}}{(p)(Lp+R)}+\frac{Li_o\epsilon^{pt}}{Lp+R}\right]$$

Each term is evaluated with the aid of theorem 1. Consider the first term. It has a first-order pole at $p=0$ and another at $p=-R/L$. To find the residue at $p=0$, let $f(p)=\frac{E\epsilon^{pt}}{Lp+R}$ and $g(p)=p$. Then $f(0)=E/R$, and $g'(0)=1$, so that the residue at $p=0$ is $\frac{f(0)}{g'(0)}=\frac{E}{R}$. To find the residue at $p=-\frac{R}{L}$, let $f(p)=\frac{E\epsilon^{pt}}{p}$ and $g(p)=Lp+R$. Then

$$f\left(-\frac{R}{L}\right)=-\frac{EL}{R}\epsilon^{-\frac{Rt}{L}} \text{ and } g'\left(-\frac{R}{L}\right)=L$$

Hence, the residue at $p=-R/L$ is

$$\frac{f\left(-\frac{R}{L}\right)}{g'\left(-\frac{R}{L}\right)}=-\frac{E}{R}\epsilon^{-\frac{Rt}{L}}$$

In a similar manner the residue of the second term at $p=-R/L$ is found by setting $f(p)=Li_o\epsilon^{-pt}$ and $g(p)=Lp+R$. The result is $i_o\epsilon^{-\frac{Rt}{L}}$. The sum of these three residues is

$$i(t)=\frac{E}{R}-\frac{E}{R}\epsilon^{-\frac{Rt}{L}}+i_o\epsilon^{-\frac{Rt}{L}} \tag{18}$$

which completes the solution to this problem.

The transform of example 2 (see equation 11) is

$$\tilde{i}=\frac{E-E_o}{Rp+\frac{1}{C}}$$

and hence

$$i(t)=\Sigma \text{ Res}\left[\left(\frac{E-E_o}{Rp+\frac{1}{C}}\right)(\epsilon^{pt})\right]$$

This function has only one pole (at $p=-1/RC$) and proceeding as before the residue is found to be

$$i(t)=\frac{E-E_o}{R}\epsilon^{-\frac{t}{RC}} \tag{19}$$

The solution for the current in mesh 1 of Figure 3, according to Equation 14, is

$$i_1(t)=\Sigma \text{ Res}\,\frac{(30)(0.1p^2+25p+10^5)\epsilon^{pt}}{(p)(1.5p^2+10{,}350p+3\times10^6)}$$

This function has three first-order poles. The first is at $p=p_1=0$. The other two are given by the solution of the quadratic $1.5p^2+10{,}350p+3\times10^6=0$. This yields the values $p_2=-6{,}600$ and $p_3=-303$. To find the residue at $p_1=0$ theorem 1 is applied with

$$f=\frac{(30)(0.1p^2+25p+10^5)\epsilon^{pt}}{1.5p^2+10{,}350p+3\times10^6}$$

and $g=p$. Then

$$\text{Res}_1=\frac{f(0)}{g'(0)}=\frac{30\times10^5}{3\times10^6}=1$$

is the residue at $p_1$. The residue at either $p_2$ or $p_3$ is found by choosing

$$f=\frac{(30)(0.1p^2+25p+10^5)}{p}\epsilon^{pt}$$

and $g=1.5p^2+10{,}350p+3\times10^6$. Then $g'(p)=3p+10{,}350$. The residue at $p_2=-6{,}600$ is

$$\text{Res}_2=\frac{f(p_2)}{g'(p_2)}=\frac{[30]\,[(0.1)(-6{,}600)^2+(25)(-6{,}600)+10^5]\,\epsilon^{-6{,}600t}}{[-6{,}600]\,[(3)(-6{,}600)+10{,}350]}$$
$$=2.063\epsilon^{-6{,}600t}$$

Similarly the residue at $p_3$ is found to be

$$\text{Res}_3=-1.065\epsilon^{-303t}$$

Hence

$$i_1(t)=1-1.065\epsilon^{-303t}+2.063\epsilon^{-6{,}600t} \tag{20}$$

By proceeding as before, the solution for $i_2$ is obtained as

$$i_2(t)=-0.033\epsilon^{-303t}+2.032\epsilon^{-6{,}600t} \tag{21}$$

At $t=0$ the mesh currents are given by

$$i_{1o}=1-1.065+2.063\approx2$$

and

$$i_{2o}=-0.033+2.032\approx2$$

which are equal. Hence, the initial current in the center branch of Figure 3 is $i_{1o}-i_{2o}=0$ as was predicted.

The foregoing examples illustrate how to obtain the residues at first-order poles. After a little experience in the proper choice of the functions $f(p)$ and $g(p)$ has been attained, a residue can be found with extreme rapidity with the aid of theorem 1. If it is remembered that when finding the residue at $p=p_s$, $g(p_s)$ must equal zero, it is a simple matter to decide which part of $\tilde{i}(p)\epsilon^{pt}$ should be taken as $f(p)$ and which part as $g(p)$.

The transform obtained in example 4 (equation 15) is

$$\tilde{i}(p)=\frac{1}{(p+100)^2}$$

which has a second-order pole at $p=-100$. Hence, theorem 2 is applied to the function

$$w=\tilde{i}(p)\epsilon^{pt}=\frac{\epsilon^{pt}}{(p+100)^2}$$

Thus

$$\left.\begin{aligned} i(t)&=\lim_{p\to-100}\frac{d}{dp}\left\{(p+100)^2\left[\frac{\epsilon^{pt}}{(p+100)^2}\right]\right\}\\ &=\lim_{p\to-100}\left(\frac{d\epsilon^{pt}}{dp}\right)=\lim_{p\to-100}(t\epsilon^{pt})\\ &=t\epsilon^{-100t}\end{aligned}\right\} \tag{22}$$

This example illustrates how the residue at a higher-order pole is obtained.

## THE CONNECTION BETWEEN TRANSFORMS AND OPERATORS

Consider a single mesh *RLC* circuit which is initially at rest and to which is applied unit direct voltage at

time $t=0$. The differential equation of the circuit is

$$L\frac{di}{dt}+Ri+\frac{q}{C}=\mathbf{1} \tag{23}$$

The corresponding operational equation is found by replacing $d/dt$ by $p$, $q$ by $1/p$ and 1 by the Heaviside unit function $\mathbf{1}$. Thus,

$$\left(Lp+R+\frac{1}{pC}\right)i=\mathbf{1}$$

or

$$Z(p)i=\mathbf{1} \tag{24}$$

where $Z(p)=Lp+R+1/pC$ is called the "operational impedance." By analogy with steady-state a-c terminology $Y(p)=1/Z(p)$ is called the "operational admittance." Hence, Heaviside's solution of this problem is

$$i=\frac{\mathbf{1}}{Z(p)}=Y(p)\mathbf{1} \tag{25}$$

The transform of equation 23, subject to initial conditions of rest, is

$$Lp\tilde{i}+R\tilde{i}+\frac{\tilde{i}}{pC}=\frac{1}{p}$$

$$\tilde{i}=\frac{1}{pZ(p)}=\frac{Y(p)}{p} \tag{26}$$

A comparison of equations 25 and 26 shows that *if the operational admittance is divided by $p$, the transform of the current is obtained.* This interpretation allows many of the Heaviside operators to be evaluated very quickly. To illustrate this point, the following operational equations derived in the first article are verified.

$$\frac{p}{(p+a)(p+b)}\mathbf{1}=\frac{\epsilon^{-at}-\epsilon^{-bt}}{b-a}\mathbf{1} \tag{27}$$

$$\frac{m(p)}{\Delta(p)}\mathbf{1}=\frac{m(0)}{\Delta(0)}\mathbf{1}+\sum_{s=1}^{n}\frac{m(p_s)\epsilon^{p_st}}{p_s\Delta'(p_s)}\mathbf{1} \tag{28}$$

$$\frac{1}{p^n}\mathbf{1}=\frac{t^n}{n!}\mathbf{1} \tag{29}$$

The operational admittance in equation 27 is

$Y(p)=\dfrac{p}{(p+a)(p+b)}$ and hence

$$\tilde{i}(p)=\frac{Y(p)}{p}=\frac{1}{(p+a)(p+b)}$$

Hence

$$i(t)=\Sigma\ \mathrm{Res}\ \frac{\epsilon^{pt}}{(p+a)(p+b)}$$

The residue at $p=-a$ is $\dfrac{\epsilon^{-at}}{-a+b}$ and the residue at $p=-b$ is $\dfrac{\epsilon^{-bt}}{-b+a}$. Hence

$$i(t)=\frac{\epsilon^{-at}-\epsilon^{-bt}}{b-a}$$

which verifies equation 27.

Equation 28 is the famous Heaviside expansion theorem and is valid only under the following restrictions: $m(p)$ and $\Delta(p)$ are polynomials with the power of $\Delta(p)$ no greater than that of $m(p)$. The roots of $\Delta(p)=0$ are $p_1, p_2, \ldots p_n$ and no two of these roots are equal. Furthermore, none of these roots is zero. This theorem is easily verified with the aid of the transform theory already developed. Thus

$$\tilde{i}(p)=\frac{m(p)}{p\Delta(p)}$$

Since $\tilde{i}(p)$ is of the form given in equation 16, then

$$i(t)=\Sigma\ \mathrm{Res}\ \frac{m(p)\epsilon^{pt}}{p\Delta(p)}$$

There are $n+1$ poles, namely, at $p=0$, $p_1$, $p_2 \ldots p_n$. The restrictions that no two of the roots of $\Delta(p)=0$ are equal and that none has the value zero mean that all the singularities are first-order poles. Hence, theorem 1 can be applied. The residue at $p=0$ is $m(0)/\Delta(0)$. The residue at $p=p_s$ is found by taking

$$f(p)=\frac{m(p)\epsilon^{pt}}{p} \text{ and } g(p)=\Delta(p)$$

Hence, the residue at $p=p_s$ is

$$\frac{m(p_s)\epsilon^{p_st}}{p_s\Delta'(p_s)}$$

The sum of the residues is

$$i(t)=\frac{m(0)}{\Delta(0)}+\sum_{s=1}^{n}\frac{m(p_s)\epsilon^{p_st}}{p_s\Delta'(p_s)}$$

which verifies equation 28.

To verify equation 29 it is noted that

$$\tilde{i}(p)=1/p^{n+1}$$

and

$$i(t)=\Sigma\ \mathrm{Res}\ \frac{\epsilon^{pt}}{p^{n+1}}$$

There is a pole of order $n+1$ at $p=0$. Hence, theorem 2 is applied with $m=n+1$ and $p_o=0$. Thus

$$i(t)=\lim_{p\to 0}\left[\frac{1}{n!}\frac{d^n}{dp^n}(\epsilon^{pt})\right]=\frac{t^n}{n!}$$

Tables of operational equations such as equations 26, 27, 28, and 29 are found in several textbooks.[3,4] For the types of operators encountered in lumped-circuit analyses it is very simple to obtain the desired time functions by the method of residues as illustrated here.

## THE INFINITE INTEGRAL THEOREM

Carson[5] bases his treatment of the operational calculus upon the integral equation

$$\frac{1}{pZ(p)}=\int_0^\infty A(t)\epsilon^{-pt}dt \tag{30}$$

where $A(t)$ is called the "indicial admittance" (that is,

the current when unit voltage is impressed) and $p$ is treated as a real positive number. The initial conditions are assumed to be those of rest. The operational impedance $Z(p)$ has already been introduced. The preceding equation is called an integral equation because the unknown function $A(t)$ appears under the integral sign. Bush[4] refers to this particular equation as the infinite integral theorem.

Carson's method consists essentially of using a table of $Z(p)$'s corresponding to assumed functions $A(t)$. Every $A(t)$ for which the integral on the right-hand side of equation 30 can be evaluated gives the solution to some problem with an impedance $Z(p)$ given by equation 30. This table is then used in the reverse order to find the $A(t)$ which corresponds to the $Z(p)$ of the particular network under consideration.

The infinite integral theorem can be used as a check on the validity of any operational results obtained by questionable means. Thus, if the value of $A(t)$ which is under suspicion is substituted in equation 30, and a $Z(p)$ calculated which is identical with the impedance operator of the network under survey, then this $A(t)$ is the true solution to the problem.

The connection between Carson's method and the transform method should be apparent. Thus, consider a circuit with an impressed voltage $e(t)$, the initial conditions being those of rest. Then $\tilde{i}(p)=\tilde{e}(p)/Z(p)$ where $Z(p)$ is the impedance transform. If the voltage is the unit function, then $\tilde{e}(p)=1/p$ and the corresponding current $i(t)$ is the indicial admittance $A(t)$. Hence, $\tilde{A}(p)=1/pZ(p)$, or, using equation 1

$$\tilde{A}(p)=\frac{1}{pZ(p)}\equiv\int_0^\infty A(t)\epsilon^{-pt}dt$$

which is the infinite integral theorem. This shows that this theorem is in reality simply the definition of the transform of the indicial admittance $A(t)$.

The power in the method presented here lies in knowing the explicit solution to the integral equation 30. For example, if $\tilde{A}(p)$ is of the form given in equation 16 then this solution is

$$A(t)=\Sigma \text{ Res } [\tilde{A}(p)\epsilon^{pt}]$$

## SUMMARY OF THE TRANSFORM METHOD

This method of solution of the most general $n$-mesh circuit with linear lumped parameters may be summarized in the following four essential steps:

1. Write down the $n$ differential equations of the network.
2. Take the transforms of these equations.
3. Solve the resulting algebraic equations for $\tilde{i}_s(p), \ldots s=1, 2, \ldots n$.
4. Obtain $i_s(t)$ by adding up the residues of $\tilde{i}_s(p)\epsilon^{pt}$ at all of its poles.

The mathematical equations in step 1 express the physical fact that the sum of the voltage drops around each of the $n$ independent meshes must be zero. In other words, these are the well-known Kirchhoff voltage-drop equations.

In step 2 the transforms are obtained by replacing every $i$ by $\tilde{i}$, every $Ldi/dt$ by $Lp\tilde{i}-Li_o$, every $q/C$ by $\dfrac{\tilde{i}}{pC}+\dfrac{e_o}{p}$ and every impressed voltage $f(t)$ by $\tilde{f}(p)$ as found from equation 1. This explains how the general impressed voltages and the arbitrary initial conditions are introduced. In a given network it is the initial current $i_o$ in each inductance and the initial voltage $e_o$ across each capacitor that must be specified before a unique solution for the network currents and voltages can be given. Thus the transform method makes use of exactly those initial currents and voltages specified in the problem. This is not true in the classical method of solution, as will be seen.

Step 2 transforms a system of $n$ differential equations in $t$ into $n$ algebraic equations in $p$. Step 3 is the solution of these $n$ algebraic equations and is carried out most systematically with the aid of determinants.

The great majority of networks give rise to functions $\tilde{i}(p)$ which possess only first-order poles. Hence step 4 is carried out very easily with the aid of theorem 1. If, however, a higher-order pole is present, theorem 2 enables the residue at this pole to be found.

## COMPARISON WITH THE OPERATIONAL METHOD

Step 1 of the preceding section is the same for all methods of analyses since it, in effect, simply defines the network under consideration.

In Heaviside's calculus step 2 consists of replacing the differential equations by operational equations obtained by substituting $p$ for every $d/dt$ and $1/p$ for every $q$. This means that initially the network has been assumed to be at rest. In order to take arbitrary initial conditions into account various circuit artifices must be employed.[4] These methods are clumsy and laborious as compared with the simple straightforward manner in which initial conditions are introduced in the transform method.

In applications of the direct operational analysis the impressed voltage often is taken as the unit function. The response to any given excitation is then calculated from the response to unit voltage by using the superposition theorem. As indicated in the first article in this series, a second method replaces the given impressed voltage as a function of time, by its operational equivalent as a function of $p$. This method depends upon the use of a table of operational equations. If the given time function is not listed in the table this method cannot be used. On the other hand, in the transform method of treating an arbitrary impressed voltage, the $p$ function $\tilde{f}(p)$ is obtained directly from the $t$ function $f(t)$ by the fundamental definition in equation 1.

After the operational current is found, the corresponding time function must be obtained. The Heaviside

method of evaluating these operational expressions was given in the article on that subject. How to translate an operational equation into a transform and then how to obtain the inverse transform in terms of a sum of residues has already been demonstrated.

The foregoing discussion shows that there is considerable similarity between the Heaviside calculus and the transform method. However the latter goes further than the former in that it treats general impressed voltages, and in particular arbitrary initial conditions, with much greater ease. Furthermore, there often is some doubt as to how to go about evaluating an operational equation or as to whether it is legitimate to carry out certain manipulations of operators. In short, the transform method supplies all that was lacking in the Heaviside calculus in mathematical rigor and also in directness and ease of application.

These statements refer specifically to circuits with lumped parameters. The power of the transform method is even greater when applied to circuits with distributed constants.

## COMPARISON WITH CONVENTIONAL CIRCUIT ANALYSIS

In order to point out the advantages of the transform method over the classical scheme, the solution to the network of Figure 3 will be reviewed by the more conventional circuit analysis. It is assumed that the reader is familiar with this method and what follows is offered merely to refresh his memory.

The solution is assumed to consist of the sum of two parts, a steady-state term and a transient term. Mathematically, these correspond to a particular integral and a complementary integral, respectively, of the network differential equations. The particular integral contains no arbitrary constants. There are a number of special methods for obtaining this part of the solution. The simplest procedure in this particular problem is to decide by physical argument what will be the steady-state behavior of the network. From Figure 3 it is seen that $i_2=0$, since the capacitor cannot pass direct current. Hence, mesh 2 acts effectively as an open circuit. Furthermore, since $i$ is constant in the steady-state condition, then $Ldi/dt=0$ and there is no voltage drop across the inductance. Hence, mesh 1 consists, effectively, of a 30-volt battery impressed across a 10-ohm resistor and a 20-ohm resistor in series. Therefore the resulting steady-state current in mesh 1 is $30/30=1$ ampere.

To find the complementary integral, the applied voltage is set equal to zero, thus making the differential equations homogeneous. Then a transient solution of the following form is assumed

$$i_1=A_1\epsilon^{\lambda t} \text{ and } i_2=A_2\epsilon^{\lambda t}$$

where $A_1$, $A_2$ and $\lambda$ are constants to be determined later.

Substituting these into equation 12 (with the 30 replaced by 0), and remembering that $q_2=\int i_2dt$ yields

$$(0.1\lambda+30)A_1-(0.1\lambda+20)A_2=0 \tag{31}$$

$$-(0.1\lambda+20)A_1+\left(0.1\lambda+25+\frac{10^5}{\lambda}\right)A_2=0 \tag{32}$$

From equation 31 it follows that

$$\frac{A_1}{A_2}=\frac{0.1\lambda+20}{0.1\lambda+30} \tag{33}$$

Similarly, equation 32 can be solved for the ratio $A_1/A_2$. If the result thus obtained is equated to the ratio given in equation 33, the following equation in $\lambda$ is obtained.

$$1.5\lambda^2+10{,}350\lambda+3\times10^6=0 \tag{34}$$

This quadratic has the roots $\lambda_1=-6{,}600$ and $\lambda_2=-303$.

Since the differential equations are linear, the principle of superposition dictates that the transient solution is the sum of two exponential terms involving the two values of $\lambda$ already found. Thus

$$\text{transient } i_1=A_{11}\epsilon^{\lambda_1 t}+A_{12}\epsilon^{\lambda_2 t} \quad \text{and}$$

$$\text{transient } i_2=A_{21}\epsilon^{\lambda_1 t}+A_{22}\epsilon^{\lambda_2 t}$$

Of these four constants, only two are independent because of the relation shown in equation 33. Thus

$$\frac{A_{11}}{A_{21}}=\frac{(0.1)(-6{,}600)+20}{(0.1)(-6{,}600)+30}=1.016$$

and

$$\frac{A_{12}}{A_{22}}=\frac{(0.1)(-303)+20}{(0.1)(-303)+30}=34.3$$

Adding transient and steady-state solution there results for the complete solution

$$\left.\begin{aligned} i_1&=1+1.016A_{21}\epsilon^{-6{,}600t}+34.3A_{22}\epsilon^{-303t} \\ i_2&=A_{21}\epsilon^{-6{,}600t}+A_{22}\epsilon^{-303t}\end{aligned}\right\} \tag{35}$$

The two constants $A_{21}$ and $A_{22}$ must now be determined from the initial conditions that the charge on the capacitor is zero and that the current in the inductance is zero at $t=0$. However, in order to solve for $A_{21}$ and $A_{22}$ from equation 35, the values of $i_1$ and $i_2$ at $t=0$ must first be deduced from the physical behavior of the network at $t=0$. If Kirchhoff's voltage-drop law is applied to the outside mesh of Figure 3 there results

$$30=10i_{1_0}+5i_{2_0} \tag{36}$$

it being remembered that the initial voltage drop across the capacitor is zero. Since there is no initial current in the inductance, then

$$i_{1_0}-i_{2_0}=0 \tag{37}$$

The solution of equations 36 and 37 gives $i_{1_0}=i_{2_0}=2$ as the initial mesh currents. Substituting these values into equation 35 yields $A_{21}=2.032$ and $A_{22}=-0.031$. The complete solution is

$$\left.\begin{aligned} i_1&=1+2.065\epsilon^{-6{,}600t}-1.063\epsilon^{-303t} \\ i_2&=2.032\epsilon^{-6{,}600t}-0.031\epsilon^{-303t}\end{aligned}\right\} \tag{38}$$

That the classical solution lacks the directness of the transform analysis should be clear from the preceding discussion. First a transient and a steady-state solution were patched together. The steady state was obtained by a separate analysis of the circuit. The transient solution led to the introduction of four arbitrary constants which were subsequently reduced to two. Another separate analysis of the network was made—this time at $t=0$—in order to deduce the initial values of $i_1$ and $i_2$ from the given fact that the network was initially at rest. Finally, these values of $i_1$ and $i_2$ allowed the determination of the remaining two constants previously introduced, thus giving the complete solution. All these steps are avoided in the transform method. The complete solution, transient plus steady-state, is obtained simultaneously and without the introduction of any arbitrary constants. Furthermore, no separate analyses of the network need be made in order to determine conditions at $t=0$ and $t=\infty$. The transform method requires a knowledge only of the initial currents in all inductances and the initial voltages on all capacitors. As already emphasized, these are exactly the conditions specified in the statement of a given problem. The classical analysis is indeed clumsy as compared with the systematic procedure of the transform method.

# Appendix

The explicit solution of the integral equation 1 now is obtained as an integral in the complex plane. Equation 17 for the inverse transform is shown to be a special case of this general solution.

Consider the ideal arrangement of a switch in series with a one-volt battery, the combination having negligible resistance, inserted between the input terminals of a network. If the time $t=0$ is taken at the instant the switch is closed, then the impressed voltage is zero for $t<0$ and unity for $t>0$. This is the Heaviside unit function **1** and is plotted in Figure 4.

In the second of these articles it was shown that this discontinuous function can be represented as an integral in the complex plane. Thus

$$\mathbf{1}=\frac{1}{2\pi j}\int_{Br}\frac{\epsilon^{pt}}{p}dp \qquad (39)$$

Figure 4

where $Br$, the Bromwich path, is any line parallel to the $j$-axis and to the right of it, that is, $x=x_0>0$ from $y=-\infty$ to $y=+\infty$.

If the time origin is taken at $t=T$, as shown in Figure 5, the delayed unit function is obtained. This is represented by $\mathbf{1}_T$ and equals zero for $t<T$ and unity for $t>T$. Thus

$$\mathbf{1}_T=\frac{1}{2\pi j}\int_{Br}\frac{\epsilon^{p(t-T)}}{p}dp \qquad (40)$$

It is desired to represent the "telegraphic dash" of Figure 6a as an integral in the complex plane. One arrangement for obtaining such a voltage is shown in Figure 7. The single-pole double-throw switch 2 is initially in position $A$ and the single-pole single-throw switch 1 is open. At $t=t_1$ switch 1 is closed and left

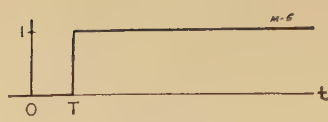

Figure 5

in this position. At $t=t_2$ switch 2 is quickly changed to position $B$ and left there. The action of switch 1 is represented by the plot in Figure 6b, and that of switch 2 by the plot in Figure 6c. Hence the combined effect of both switches is to impress a voltage which is the (algebraic) sum of these individual voltages. The addition of Figures 6b and 6c gives the telegraphic dash of Figure 6a. Thus

$$\text{telegraphic dash}=f(\mathbf{1}_{t1}-\mathbf{1}_{t2})$$

If $t_1=T$ and $t_2=T+\Delta T$, then a dash commencing at $t=T$ and of duration $\Delta T$ and height $f(T)$ is represented by

$$\frac{1}{2\pi j}\int_{Br}\frac{f(T)\epsilon^{p(t-T)}}{p}dp-\frac{1}{2\pi j}\int_{Br}\frac{f(T)\epsilon^{p(t-T-\Delta T)}}{p}dp$$
$$=\frac{1}{2\pi j}\int_{r}\left[\frac{f(T)\epsilon^{p(t-T)}}{p}dp\right][1-\epsilon^{-p\Delta T}]$$

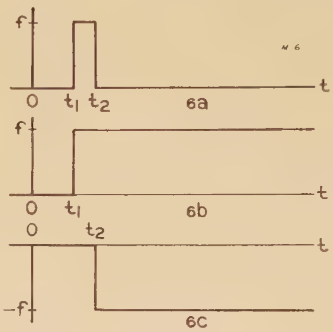

Figure 6

If $\Delta T$ is taken very small (a "dot" instead of a "dash") then $\epsilon^{-p\Delta T}$ can be expanded into $1-p\Delta T$, all higher powers in $\Delta T$ being negligible. Then the preceding equation becomes

$$\frac{1}{2\pi j}\int_{Br}f(T)\epsilon^{p(t-T)}dp\Delta T \qquad (41)$$

An arbitrary function of time $f(t)$ can be approximated by a "step" function as shown in Figure 8a. Furthermore, this broken curve may be considered to be a sum of telegraphic dots. Thus Figure 8a is the sum of Figures 8b, 8c, 8d, and so on. The height of the rectangle beginning at $t=T$ and ending at $t=T+\Delta T$ is denoted by $f(T)$ as indicated in Figure 8c. This rectangle is represented analytically by equation 41. If the usual limiting process in integral calculus is applied, then $\Delta T$ is replaced by $dT$ and the summation is changed to an integration from zero to infinity. Thus

$$f(t)=\frac{1}{2\pi j}\int^{\infty}\int_{Br}f(T)\epsilon^{p(t-T)}dpdT \qquad (42)$$

This is known as the Bromwich-Fourier integral.

If it is recalled that the definition of the Laplacian transform is

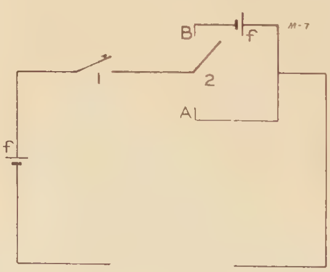

Figure 7

$$\tilde{f}(p)=\int_0^{\infty}f(T)\epsilon^{-pT}dT$$

then equation 42 may be written as

$$f(t)=\frac{1}{2\pi j}\int_{B}\tilde{f}(p)\epsilon^{pt}dp \qquad (43)$$

provided that these integrals are convergent. This is the desired result, since if $\tilde{f}(p)$ is found from the network equations its inverse $f(t)$ is given by this explicit integral in the complex plane.

If $\tilde{f}(p)$ is of the form given in equation 16, namely

$$\tilde{f}(p)=\frac{a_0+a_1p+a_2p^2+\ldots+a_np^n}{b_0+b_1p+b_2p^2+\ldots b_mp^m} \qquad (44)$$

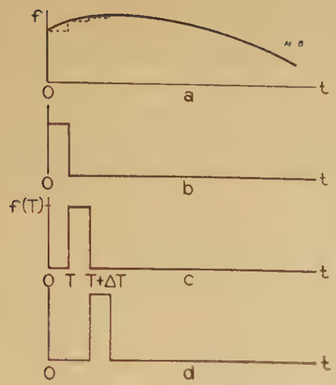

**Figure 8**

then equation 43 can be replaced by a sum of residues. To prove this, consider $\frac{1}{2\pi j}\int \tilde{f}(p)\epsilon^{pt}dp$ taken over the path shown in Figure 9. The straight line $AB$ is parallel to the $j$-axis. The rest of the path is a circular arc of radius $R$ about the origin. That the integral over the path $BCDEA$ vanishes as $R$ approaches $\infty$ is shown by using the following theorem.

*Theorem.* If the maximum value of $w(p)$ is $M$ along a path $c$ then the maximum value of the integral of $w$ along $c$ is $Ml$ where $l$ is the length of $c$. Expressed analytically,

$$\left|\int_c w dp\right| \leq Ml \tag{45}$$

This theorem follows directly from the definition of integration.

For large values of $R$, remembering that $p=R\cos\theta+jR\sin\theta$,

$$|w| = |\tilde{f}(p)\epsilon^{pt}| = \frac{a_n\epsilon^{tR\cos\theta}}{b_m R^{m-n}} \tag{46}$$

The length $l$ of the arc $CDE$ is $\pi R$. Hence, from equations 45 and 46 it follows that

$$\left|\int_{CDE} \tilde{f}(p)\epsilon^{pt}dp\right| \leq \frac{a_n\pi\epsilon^{tR\cos\theta}}{b_m R^{m-n-1}}$$

Over this arc, $\cos\theta$ is negative (or zero) since $-\pi/2\leq\theta\leq\pi/2$. Also $m>n$. Hence the preceding expression vanishes as $R$ approaches $\infty$.

Over the arc $BC$

$$\left|\int_{BC} \tilde{f}(p)\epsilon^{pt}dp\right| \leq \frac{a_n\psi\epsilon^{tR\cos\theta}}{b_m R^{m-n-1}} \tag{47}$$

since the length $l$ of the arc $BC$ is $R\psi$.

The largest possible value of $R\cos\theta$ is $x_0$ and hence the largest value of the exponential is $\epsilon^{tx_0}$ which is finite. Also $m>n$. As $R$ approaches $\infty$, $\psi$ approaches zero as can be seen from Figure 9. Hence, equation 47 approaches zero as $R$ approaches infinity.

In a similar manner it is shown that the integral over the arc $EA$ vanishes for infinite $R$. Hence

$$\lim_{R\to\infty}\left[\frac{1}{2\pi j}\int_{ABCDEA}\tilde{f}(p)\epsilon^{pt}dp\right] = \lim_{R\to\infty}\left[\frac{1}{2\pi j}\int_{AB}\tilde{f}(p)\epsilon^{pt}dp\right]$$

The right-hand side of this equation is the Bromwich integral. The left-hand side is, by definition, the sum of all the residues of $\tilde{f}(p)\epsilon^{pt}$. This completes the proof that if $\tilde{f}(p)$ is given by equation 44, then equation 43 may be replaced by a sum of residues.

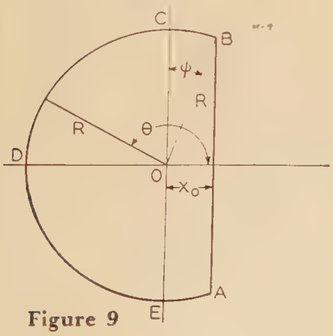

**Figure 9**

It must be emphasized that if $\tilde{f}(p)$ is not of the form given in equation 44, its inverse must be found, using equation 43 instead of a sum of residues. Such is the case in most circuits with distributed parameters.

In conclusion, the connection between the preceding analysis and the classical Fourier integral is shown. If in equation 42 $p$ is taken equal to $jy$ then this equation reduces to

$$f(t) = \frac{1}{2\pi}\int_0^{\infty}\int_{-\infty}^{+\infty} f(T)\epsilon^{jy(t-T)}dydT \tag{48}$$

This is one form of the Fourier integral.* Since $p=x_0+jy$ was replaced by $p=jy$ then the Bromwich path has been moved so as to coincide with the $j$-axis. Such a procedure is *not* valid if $\tilde{f}(p)$ has singularities along the $y$-axis. Hence, the Bromwich-Fourier integral (equation 42) must be considered as an important generalization of the Fourier integral (equation 48).

The foregoing discussion shows why it is possible to use the table of Fourier integrals by Campbell and Foster[6] in the evaluation of inverse transforms.

* If in Figure 8 $f(t)$ had not been considered equal to zero for $t<0$ then the integration over $T$ in equation 48 would have extended from $-\infty$ to $+\infty$ instead of from $0$ to $\infty$.

# References


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4. Operational Circuit Analysis (book), **V. Bush.** John Wiley and Sons, New York, 1929.

5. Electric Circuit Theory and Operational Calculus (book), **J. R. Carson.** McGraw-Hill Book Company, New York, 1926.

6. Fourier Integrals for Practical Applications, **G. A. Campbell** and **R. M. Foster.** Bell Telephone System Monograph B-584, September 1931.


# Stroboscopic Lamps Studied

Light produced by a capacitor discharge into a gas-filled tube has been utilized for scientific photographic studies for some 30 years. Now the method has been improved so that large quantities of light can be produced, and ways have been developed for accurate control of the flash.

Studies of "Electrical Characteristics of Stroboscopic Flash Lamps" were reported upon in the December 1941 issue of the *Journal of Applied Physics*, by P. M. Murphy and H. E. Edgerton of Massachusetts Institute of Technology. This paper describes the electrical characteristics of gas-filled discharge tubes when flashed by a capacitor discharge. The stated object of the experiments was the determination of two dimensions, pressure, voltage, and capacitance upon performance. The results reported are of an experimental nature and cover a limited range of values and circuit constants with tubes that were considered to be practical at the time the investigation was made. An empirical constant called "tube resistance" is defined and evaluated, and the constant is stated to be useful in predicting the performance of tubes in electric circuits.

# INSTITUTE ACTIVITIES

## North Eastern District Meeting to Be Held at Schenectady, April 29–May 1

The AIEE North Eastern District meeting to be held in Schenectady, New York, April 29–May 1, 1942, includes seven conference sessions and an unusually large number of special features, in addition to a general session, three technical sessions, and a student session. Meeting headquarters will be in the Hotel Van Curler.

The city of Schenectady, originally a Dutch settlement founded by Arendt Van Curler in 1661, was one of the frontier settlements during the French and Indian wars and occupies an important place in historic narratives of those times. The Adirondack Mountains to the north, a favorite vacation land in summer and winter, the Catskills to the south, the Hudson River Valley, and the Mohawk Valley, stretching westward into central New York, are all picturesque and interesting regions. Schenectady has a population of about 90,000, and since 1936, has operated under a city-manager-council form of government charter. Industrially, it is notable as the home of the American Locomotive Company and the General Electric Company.

The opening session on Wednesday morning, April 29, will be addressed by well-known men in the fields of engineering and research on the subject of the work being done by the electrical industry to win the war and the peace to follow.

### SPECIAL FEATURES

A dinner featuring special entertainment will be held on Wednesday evening for men only, with novel radio sketches presented by members of the Schenectady Section. The program will be headed by Frazier Hunt, CBS radio commentator. Tickets are $2.00 each.

A special luncheon open to all will be held at noon on Thursday, April 30. An address will be made by Lewis A. Wilson, New York State Deputy Commissioner of Education on "Needs and Trends of Vocational Education." The luncheon will adjourn for the afternoon conference, at which addresses will be made by Alonzo

## North Eastern District Meeting

### Wednesday, April 29

**9:00 a.m. Registration**

**10:00 a.m. General Session**

**T. M. Linville**, presiding

Address of welcome. **Everett S. Lee**, vice-president, North Eastern District

Address, "AIEE Progress." **H. H. Henline**, national secretary

Address, "Wartime Electrical Research." **L. A. Hawkins**, executive engineer, research laboratory, General Electric Company

Address, "Wartime Electrical Engineering." **R. C. Muir**, vice-president, General Electric Company

Address, "Planning for Peace." **D. C. Prince**, President

**2:00 p.m. Electronics and Communication**

**S. B. Ingram**, presiding

CP.* Ultrahigh-Frequency Phenomena. **S. Ramo**, General Electric Company

CP.* The Use of High-Frequency Modulation for Communication. **H. Duval, Jr.**, General Electric Company

CP.* Regulated Rectifiers for Telephone Offices. **D. E. Trucksess**, Bell Telephone Laboratories, Inc.

42-81. High-Frequency Coaxial-Line Calculations. **H. H. Race, C. V. Larrick**, General Electric Company

**2:00 p.m. Conference on Mercury Power Plants**

**A. R. Smith**, presiding

CP.* Fundamentals of Mercury. **A. R. Smith**, managing engineer, turbine department, General Electric Company

CP.* Up-to-Date Mercury Developments. **A. J. Nerad**, research laboratory, General Electric Company

CP.* Mercury Apparatus Design. **L. A. Sheldon**, turbine engineering department, General Electric Company

CP.* Special Instruments. **T. T. Woodson**, research laboratory, General Electric Company

CP.* Mercury Plant Operation and Maintenance. **T. M. Doran**, turbine engineering department **Frank Horrocks**, mercury power station, General Electric Company

CP.* Mercury Applications. **H. N. Hackett**, construction engineering department, General Electric Company

**4:00 p.m. Inspection Trip to General Electric Television Studio WRGB**

**7:00 p.m. Dinner**

Featuring Frazier Hunt, CBS radio commentator. Radio sketches by Schenectady Section, AIEE

### Thursday, April 30

**9:00 a.m. Power and Machinery**

**C. M. Gilt**, presiding

42-85. Standardized Load-Center Unit Substations for Low-Voltage A-C Systems. **E. M. Hunter, J. C. Page**, General Electric Company

42-84. Calorimetric Method for Determining Efficiencies of Electric Machines. **Victor Siegfried, C. W. Thulin**, Worcester Polytechnic Institute

42-75. Theory of the Brush-Shifting A-C Motor, Part III—Power-Factor Correction. **A. G. Conrad, F. Zweig, J. G. Clarke**, Yale University

42-76. Theory of the Brush-Shifting A-C Motor. Part IV—Speed Control With Power-Factor Correction. **A. G. Conrad, F. Zweig, J. G. Clarke**, Yale University

42-80. High-Voltage Fusing of Transformer Banks. **H. H. Marsh, Jr., G. B. Dodds**, Duquesne Light Company

**9:00 a.m. Conference on Conservation of Critical Materials by the Use of Substitutes**

**A. L. Rumsey**, presiding

CP.* Title to be announced. **J. R. Townsend**, Bell Telephone Laboratories, Inc.

**● PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in this program may be obtained as noted in the following paragraphs.**

**● ABSTRACTS of papers appear on pages 210–11 of this issue.**

**● PRICES and instructions for securing advance copies of these papers accompany the abstracts. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper**

**10:00 a.m. Inspection Trip**

Technical training program—Mont Pleasant High School, Schenectady, N. Y.

**10:30 a.m. Conference on Power Problems Presented by Municipal Black-Outs in the Albany District**

**J. L. Harvey**, presiding

CP.* In the Telephone Field. **C. F. Monnier** New York Power and Light Company

**12:00 m. Luncheon Jointly with The American Society of Mechanical Engineers, Schenectady Section.**

**W. H. Timbie**, presiding

Address, "Needs and Trends in Vocational Education." **Lewis A. Wilson**, New York State Deputy Commissioner of Education

**2:00 p.m. Conference on Vocational Education, Jointly with ASME**

**W. H. Timbie**, presiding

Address, **Alonzo Grace**, Commissioner of Education, State of Connecticut

Grace, Commissioner of Education, State of Connecticut; C. E. Crofoot, Principal, Mont Pleasant Technical High School, Schenectady; and W. H. Pillsbury, Superintendent of Schools, Schenectady, N. Y. This program is sponsored jointly by the Schenectady Sections of the AIEE and The American Society of Mechanical Engineers. Tickets for the luncheon are $1.25.

On Thursday afternoon a program entitled "New Developments" will be given in Rice Hall of the General Electric Company by the Research Laboratory and the General Engineering Laboratory of the company. Members and guests attending must be United States citizens and must enter the General Electric plant only in buses departing from the Hotel Van Curler. Transportation charge will be $0.25 for the round trip.

The 15th Steinmetz memorial lecture will be given Thursday evening in the Memorial Chapel on the Union College campus, by Comfort A. Adams on the subject of "Co-operation vs. War." Doctor Adams was president of the Institute in 1918–19 and 1940 Lamme Medalist. He is best known for his contributions to the theory and design of a-c machinery and his work in the field of electric welding. He organized and was the first president of the American Welding Society.

The Steinmetz lectures are made possible at intervals by the income from the Steinmetz Memorial Foundation, established by funds contributed by the personal friends and associates of Doctor C. P. Steinmetz. The income is administered by the AIEE Schenectady Section.

Friday, May 1, the students attending the meeting will be the guests of the General Electric Company at luncheon at the Hotel Van Curler. They will be addressed by M. M. Boring on "The Effect of War on Young Engineers Inducted into Industry." Tickets can be purchased by older members wishing to attend.

A banquet will be held at the Hotel Van Curler on Friday evening, with informal talks by several distinguished guests and presentation of prizes by Vice-President Everett S. Lee. Mr. and Mrs. Lee will receive members and guests before the dance. Tickets for the banquet and dance are $2.75; students' tickets $1.75.

TRIPS

Wednesday afternoon an inspection trip and demonstration will be staged at television studio WRGB. On Thursday morning the technical courses and facilities at the Mont Pleasant High School will be inspected. Friday afternoon an inspection trip will be conducted to the Schenectady General Depot of the United States Army. Bus fare $0.25. Limited to United States citizens.

WOMEN'S PROGRAM

On Wednesday afternoon there will be an inspection of the grounds and gardens of Union College. A bridge party will be held that evening in the solarium of the Hotel Van Curler. On Thursday morning a trip will be made to the Mohawk Carpet Mills at Amsterdam, N. Y., returning after lunch. The transportation cost is $0.25 for the round trip. On

# Technical Program and Features

**at the meeting cannot be assured. Only numbered papers are available in pamphlet form.**

● **COUPON books in $5.00 denominations are available for those who may wish this convenient form of remittance.**

● **ALL PAPERS regularly approved by the technical program committee ultimately will be published in Transactions; many will appear also in Electrical Engineering.**

42-77-ACO.** THE TECHNICAL HIGH SCHOOL TRAINS FOR LIFE. **C. E. Crofoot**, principal, Mont Pleasant Technical High School, Schenectady, N. Y.

Address, "The New Vocational High School Project for Schenectady." **W. H. Pillsbury**, Superintendent of Schools, Schenectady, N. Y.

### 2:00 p.m. Conference on Operation of Mercury-Arc Rectifiers

**C. C. Herskind**, presiding

Sponsored by the rectifier subcommittee of the committee on electrical machinery, to provide opportunity for discussion of experiences

### 4:30 p.m. Program

Presented by General Electric Research Laboratory and General Engineering Laboratory, Rice Hall, General Electric Company

### 6:00 p. m. North Eastern District Executive Committee Dinner Meeting

### 8:15 p.m. Steinmetz Memorial Lecture, Memorial Chapel, Union College

Address, "Co-operation Versus War." **Comfort A. Adams**, past president, AIEE, and consulting engineer, Edward G. Budd Manufacturing Company

## Friday, May 1

### 9:00 a.m. Student Session

**E. A. Walker**, presiding

Titles and authors of selected papers to be announced

### 12:00 m. Student Luncheon

**E. A. Walker**, presiding

Address, "The Effect of War on Young Engineers Inducted into Industry." **M. M. Boring**, General Electric Company

### 2:00 p.m. Selected Subjects

**J. J. Orr**, presiding

42-78. REACTANCE AND SKIN EFFECT OF CONCENTRIC TUBULAR CIRCUITS. **H. B. Dwight**, Massachusetts Institute of Technology

42-82. TEMPERATURE AGING TESTS ON CLASS A INSULATED FRACTIONAL HORSEPOWER MOTOR STATORS. **J. A. Scott, B. H. Thompson**, General Electric Company

42-79. THERMAL CO-ORDINATION OF MOTORS, CONTROL, AND THEIR BRANCH CIRCUITS ON POWER SUPPLIES OF 600 VOLTS AND LESS. **B. W. Jones**, General Electric Company

42-86. SELENIUM RECTIFIERS AND PRINCIPLES OF THEIR DESIGN. **John E. Yarmack**, International Telephone and Radio Manufacturing Corporation

42-83. RECTIFIER TERMINOLOGY AND CIRCUIT ANALYSIS. **C. H. Willis**, Princeton University, **C. C. Herskind**, General Electric Company

### 2:00 p.m. Conference on Statistical Methods for Quality Control

**R. E. Wareham**, presiding

CP.* QUALITY CONTROL IN RELATION TO ENGINEERING TOLERANCES. **H. F. Dodge**, Bell Telephone Laboratories, Inc.

CP.* QUALITY CONTROL AND PRODUCTION PROBLEMS. **J. Maneuele**, Westinghouse Electric and Manufacturing Company

### 2:00 p.m. Conference on Diesel-Electric Locomotives

**J. C. Davidson**, presiding

CP.* Opening remarks. **J. C. Davidson**, American Locomotive Company

CP.* COMMERCIAL TESTING OF DIESEL LOCOMOTIVES. **M. C. Swanson**, American Locomotive Company

CP.* ANTIVIBRATION MOUNTING OF DIESEL LOCOMOTIVES. **E. L. Thearle**, General Electric Company

CP.* DIESEL LOCOMOTIVE MOTORS AND CONTROL. **J. W. Tecker**, General Electric Company
Sound Motion Picture, "Railroadin' " presented by American Locomotive Company, General Electric Company, and the American Railroads

### 2:00 p.m. Inspection Trip

Schenectady General Depot, United States Army.

### 4:00 p.m. Student Branch Counselors' Committee Meeting

### 7:00 p.m. Banquet

**Everett S. Lee**, Vice-President, AIEE, presiding

Address, "Liberal Arts in the Life of the Engineer." **W. O. Hotchkiss**, President, Rensselaer Polytechnic Institute

Address, "Technical Arts in the Life of the Engineer." **D. R. Fox**, President, Union College

Address, "The AIEE in the Life of the Engineer." **D. C. Prince**, President, AIEE

### 9:30 p.m. Reception

Solarium, Van Curler Hotel

### 10:00 p.m. Dancing

Ballroom, Van Curler Hotel

*CP.: Conference paper; no advance copies available; not intended for publication in *Transactions*.

**ACO.: Advance copies only available; not intended for publication in *Transactions*.


**A 2,000-horsepower Diesel-electric locomotive at the plant of the American Locomotive Company, Schenectady, N. Y.; a conference on Diesel-electric locomotives will be held during the AIEE North Eastern District meeting**

Friday afternoon a tea and reception will be held at the Mohawk Golf Club. Women are cordially invited to attend the trip to the WRGB Television Studios Wednesday afternoon and the Steinmetz Memorial Lecture Thursday evening.

Golfing privileges will be available for men and women at the Mohawk Golf Club and the Edison Country Club. Tennis courts will be available at both clubs, weather permitting. No tournaments will be arranged.

RESERVATIONS AND REGISTRATION

Members and guests should make their hotel reservations as far in advance as possible by writing directly to the Hotel Van Curler, meeting headquarters.

Members are asked to register in advance and complete their registration upon arrival at the meeting. A registration fee of $2.00 will be charged all nonmembers except Enrolled Students and the immediate families of members. Advance registration is necessary for trips which will be limited to United States citizens. This information should reach Schenectady by April 15.

COMMITTEES

*District meeting:* Everett S. Lee, *chairman;* R. G. Lorraine, *secretary;* E. B. Alexander, D. E. Chambers, H. D. Griffith, C. F. Harris, T. M. Linville, J. M. Murray, G. M. L. Sommerman.

*Executive:* T. M. Linville, *chairman;* P. L. Alger, G. W. Brucker, J. W. Butler, D. E. Chambers, C. E. Crofoot, F. E. Danford, J. C. Davidson, J. J. Farrell, K. R. Geiser, J. L. Harvey, S. A. Holme, C. E. Kilbourne, William Kruesi, Everett S. Lee, Mrs. Everett S. Lee, H. H. Race, A. L. Rumsey, F. M. Sebast, R. V. Shepherd, R. C. Sogge, Mrs. A. C. Stevens, I. A. Terry, E. A. Walker.

*Meetings and papers:* H. H. Race, *chairman;* R. F. Franklin, O. C. Rutledge, J. J. Smith.

*Vocational education conference and luncheon:* P. L. Alger, *chairman;* C. E. Crofoot, H. H. Race, R. V. Shepherd.

*Hotels and registration:* J. W. Butler, *chairman;* R. C. Buell, B. H. Caldwell, N. H. Meyers, W. E. Miller, B. R. Prentice, T. W. Schroeder.

*Publicity:* S. A. Holme, *chairman;* G. W. Dunlap, J. A. Pauze, E. Littlejohn Robinson, K. B. Wagner.

*Trips:* I. A. Terry, *chairman;* F. E. Crever, L. J. Goldberg, W. E. Jacobsen, W. M. Nelson.

*Finance:* K. R. Geiser, *chairman.*

*Smoker and sports:* R. C. Sogge, *chairman;* E. H. Bancker, J. W. Cooke, J. J. Farrell, C. G. Fick, J. J. Huether, C. C. Leader, Simon Ramo, A. C. Stevens, C. A. Woodrow.

*Reception:* G. W. Brucker, *chairman;* B. D. Bedford, R. B. Bodine, W. K. Boice, S. B. Crary, S. B. Farnham, R. H. Greene, M. N. Halberg, C. C. Herskind, W. C. Hutchins, H. L. Kellogg, C. J. Koch, P. H. Light, D. H. McAllister, M. M. Morack, L. W. Morton, L. M. Nowacki, H. E. Peterson, A. W. Rankin, T. R. Rhea, W. Ridgway, August Schmidt, Jr., C. J. Semrad, D. S. Snell, A. Stephenson, E. R. Summers, H. D. Taylor.

*Student meeting:* E. A. Walker, *chairman;* A. G. Conrad, L. C. Holmes, C. E. Kilbourne, Victor Siegfried.

*Student hospitality:* W. R. Kruesi, *chairman;* F. M. Gager, L. C. Holmes, C. E. Kilbourne, E. A. Walker.

*Banquet:* F. E. Danford, *chairman;* Fremont Felix, R. B. Russ, R. H. Spry, A. L. Thurman, P. W. Worthen.

*Women's entertainment:* Mrs. A. C. Stevens and Mrs. Everett S. Lee, *co-chairmen;* Mrs. P. L. Alger, Mrs. S. B. Crary, Mrs. D. R. Fox, Mrs. T. M. Linville, Mrs. R. G. Lorraine, Mrs. R. C. Muir, Mrs. D. C. Prince, Mrs. H. H. Race, Mrs. R. C. Sogge, Mrs. A. R. Stevenson, Jr., Mrs. W. C. White, Mrs. H. A. Winne, Mrs. T. A. Worcester.

**The campus of Union College, Schenectady, N. Y. The building to the right with the cupola is Memorial Chapel where the Steinmetz Memorial Lecture will be delivered**

# NATIONAL • • • •

## Arrangements Progressing for 1942 Summer Convention

The annual AIEE summer convention will be held in Chicago, Ill., June 22–26, 1942. Convention headquarters will be in the Drake Hotel, located on the shore of Lake Michigan, where excellent beach facilities are available. Even though Chicago is doing its full part in the war effort it will be possible for members and guests to visit many museums and points of interest in the city during the convention. The Chicago Association of Commerce is co-operating with the summer convention committee to insure that all who attend the meeting will be well entertained.

Because of the war, the board of directors has recommended that the summer convention be made a working convention. While at this date it is impossible to mention specifically the sessions and conferences to be scheduled, several will be closely related to the war effort. For example, a symposium on mercury-arc rectifier applications has been proposed, because, as a result of the increase in electrochemical power requirements, it has been estimated that rectifiers will consume approximately one-fourth of the total power generated in the United States. The committee on education is planning to hold an informal round-table conference on educational matters as related to wartime conditions. Among technical sessions in prospect are the following: switching equipment, protective relays, lightning, communication, symposium on overload operation of transformers and rotating machinery, and land transportation. Several other interesting and timely conferences, as well as a general session on subjects of broad interest are under consideration.

To complete the business program the annual meeting, the conference of officers, delegates, and members, and the conference of Branch counselors will be held as usual. Other details will be announced later as they become available.

The personnel of the 1942 summer convention committee making the arrangements is:

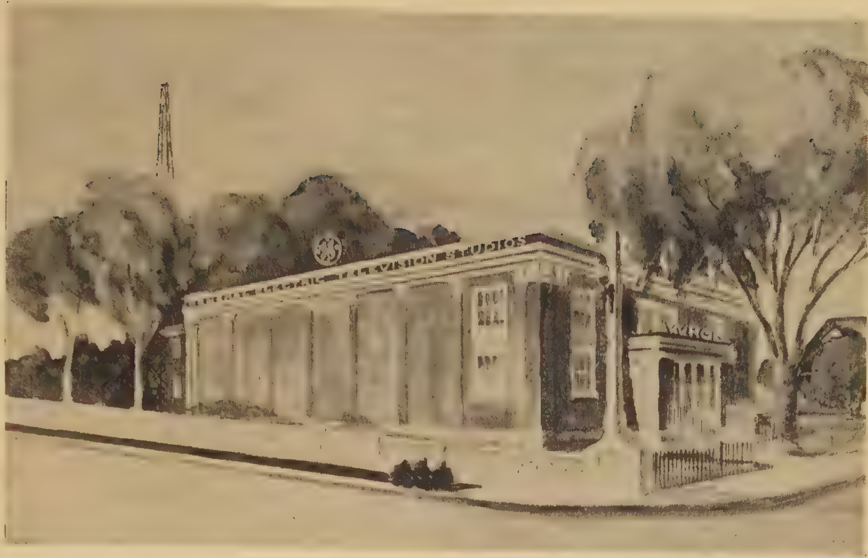
H. B. Gear, *chairman;* P. B. Juhnke, *vice-chairman;* N. C. Pearcy, *secretary;* K. A. Auty, *treasurer;* M. S. Coover, K. V. Glentzer, K. L. Hansen, J. C. Woods.

Chairmen of the subcommittees are:

H. W. Eales, *sports;* J. A. Fitts, *special events;* J. E. Kearns, *hotel;* A. M. Jackson, *acting chairman, hotel;* F. H. Lane, *finance;* T. G. LeClair, *technical program;* Mrs. L. R. Mapes, *women's entertainment;* L. R. Mapes, *dinner-dance;* D. L. Smith, *transportation and trips;* F. V. Smith, *registration;* H. K. Smith, *publicity.*

## Wickenden Article Available in Reprint Form

The article on "A Peace Worth Fighting For" by Doctor William E. Wickenden (F'39) president of the Case School of Applied Science, Cleveland, Ohio, which was originally presented as an address at the 1942 AIEE winter convention and published in the March 1942 issue of *Electrical Engineering*, has attracted such widespread and favorable attention that it is being reprinted for general distribution. Copies may be obtained from AIEE order department, 33 West 39th Street, New York, N. Y., at 15 cents per single copy; 10 per cent discount on quantities of 10 or more.



**The architect's drawing of the new General Electric Television Studio WRGB, Schenectady, N. Y., to be inspected during the North Eastern District meeting**

# SECTION • • • • •

## Electron-Microscope Metals Study Described at Fort Wayne

The way the electron microscope is being applied to discover how metals harden was described at a recent meeting of the AIEE Fort Wayne Section, Fort Wayne, Ind., by Doctor David Harker, research laboratory, General Electric Company.

To develop alloys which will withstand the operating conditions encountered in such uses as airplane engines or high-speed marine turbines, it is necessary to know how the crystals form in the early stages of changes in metals, Doctor Harker pointed out. The electron microscope, which has a magnifying power 50 times that of the best optical microscopes, is used to observe these changes. Since metal is opaque to the electrons, the specimens to be observed are dipped into a solution of synthetic resin. The liquid evaporates and the remaining film of resin, which retains all details of the metal surface, can be stripped off and examined in the electron microscope. The method was developed by V. J. Schaefer of the General Electric laboratory, Doctor Harker said. (For a description of the electron microscope, see "Electrons Extend the Range," by Vladimir Zworykin, *EE, Nov. '40, p. 441–3.*)

### Future AIEE Meetings

**North Eastern District Meeting**
Schenectady, N. Y., April 29–May 1, 1942

**Summer Convention**
Chicago, Ill., June 22–26, 1942

**Pacific Coast Convention**
Vancouver, B. C., September 9–11, 1942

**Middle Eastern District Meeting**
Pittsburgh, Pa., October 14–16, 1942

**Winter Convention**
New York, N. Y., January 25–29, 1943

## Science and Engineering in the War Effort

How scientists and engineers can contribute to the war program is a subject of timely interest that many AIEE Sections wishing to render a public service can discuss to advantage, and thereby implement recent recommendations for broader Section activities (*EE, March '42, p. 148–52*). A currrent meeting at which this subject will be discussed is a joint meeting to be held under auspices of the AIEE New York Section and the New York Electrical Society at which Doctor L. A. DuBridge, director of the radiation laboratory, Massachusetts Institute of Technology, Cambridge, will be the principal speaker. The meeting is being sponsored by the basic-science group of the Section and will be held April 15, 1942.

Doctor DuBridge will discuss the present way in which scientists and engineers are organized to contribute to the war program. He will outline the civilian organizations, the contributions of the industrial laboratories, and the co-operation with the armed services. The future needs of these organizations for scientists and engineers

will be outlined. There will be a discussion of how large and vital a part scientists and engineers must play in this war.

# ABSTRACTS • • •

**TECHNICAL PAPERS previewed in this section will be presented at the AIEE North Eastern District meeting, Schenectady, N. Y., April 29–May 1, 1942, and are expected to be ready for distribution in advance pamphlet form within the current month. Copies may be obtained by mail from the AIEE order department, 33 West 39th Street, New York, N. Y., at prices indicated with the abstract; or at five cents less per copy if purchased at AIEE headquarters or at the meeting registration desk.**

**Mail orders will be filled AS PAMPHLETS BECOME AVAILABLE**

## Basic Sciences

**42-78—Reactance and Skin Effect of Concentric Tubular Conductors;** *Herbert B. Dwight (F '26). 25 cents by mail.* The concentric arrangement of tubular conductors to carry heavy alternating currents, single-phase or three-phase, gives compactness, low reactance drop, and reduced loss from skin effect, that is, crowding of the current to the surface of the conductors. Concentric tubular circuits are used also at higher frequencies than 60 cycles, as, for instance, in communication circuits. Formulas for reactance and skin effect of such circuits are given. Formulas suitable for three-phase circuits at power frequencies are included. For the single-phase case, formulas 30 and 35 are given, which involve Bessel functions directly and require tabulated numerical values of those functions. Under favorable conditions, series formulas may be more convenient, and among these, formulas 36 and 37 are suitable for high frequencies, omitting the effect of radiation. The conditions under which the well-known "penetration formula," for high frequencies may be used are described in detail. Numerical examples are given, and a set of curves presented, which saves the labor of computing by formulas for cases where the curves apply.

**42-81—High-Frequency Coaxial-Line Calculations;** *H. H. Race (F '39), C. V. Larrick (A '40). 20 cents by mail.* The first part presents formulas and data necessary to calculate solid dielectric coaxial-line characteristics, particularly attenuation and surge impedance from physical dimensions and known properties of the conducting and insulating materials. Considerable emphasis is placed upon the limits of applicability of the simple high-frequency formulas in general use. Examples are given showing that at 25 kilocycles these formulas lead to considerable error, so that exact relations must be used. In the second part are presented formulas and graphs for the ratio of terminal voltages as a function of the phase angle of the line for several types of load for both dissipationless and dissipative lines. These relations are helpful in understanding observed voltage variations with frequency caused by reflections, particularly on short lengths of line. In the third part, a derivation is indicated leading to a general equation for the efficiency of transmission. Simplifications are made which are often applicable in practice and curves are plotted showing the effect of mismatch in reducing efficiency.

## Education

**42-77-ACO—The Technical High School Trains for Life;** *C. E. Crofoot (M '28). 15 cents by mail.* This paper describes the comprehensive technical course which is given at the Mont Pleasant High School in Schenectady with the aim of training boys for constructive work in industry and throughout life. The course grew out of the realization that boys interested in engineering should have an opportunity to try their hands in practical laboratory or construction work, at the same time they are learning the elements of mathematics and science in school. A technical course was therefore, designed to be operated within the large academic Mont Pleasant High School, and special facilities were provided in designing the building. The course was arranged to suit boys who intend to go directly into the technical branches of industry after high school, but it was found that the same requirements were suited very well to boys going on to engineering colleges. In either case, the boys profit greatly from the opportunity to make actual trial of the work they intend to enter, and this experience has proved equally useful in industry and as a preliminary to engineering college. An important feature of this type of school is that it aims directly at serving the local industries. Distinctive types of school are, therefore, desirable in different localities. The successful record of the graduates from this Mont Pleasant course over the past ten years has aroused wide interest in the plan throughout New York State. The paper is offered, therefore, with the object of encouraging further development of this type of training in other industrial areas.

## Industrial Power Applications

**42-79—Thermal Co-ordination of Motors, Control, and Their Branch Circuits on Power Supplies of 600 Volts and Less;** *B. W. Jones (A '11). 15 cents by mail.* In conformity with the war effort to conserve materials, especially copper and nickel, a method is discussed for determining the minimum cross-section of copper and Nichrome that can be used on motors, motor control, and branch circuits and still provide adequate current-carrying ability during overload or short-circuit conditions. The required characteristics of the overload and short-circuit means are also discussed.

**42-85—Standardized Load-Center Unit Substations for Low Voltage A-C Sysems;** *E. M. Hunter (M '36) and J. C. Page (A '41). 20 cents by mail.* One of the recent important contributions of electrical manufacturers to the field of low voltage a-c systems has been the development and standardization of the load-center unit substation to service load areas such as buildings, mines, yards, docks, camps, with low voltage a-c power at utilization voltage. Low voltage a-c distribution systems are usually classified in one of four groups, namely, the simple radial system, the primary preferred emergency system, the secondary selective system, and the network system. Each of these systems has a definite field of application which must be met by the substation equipments. This paper presents (1) a definition of a load-center unit substation, (2) the general requirements which have been met by the standardized line, (3) a description of units with illustrations and (4) tables for the ready selection of load-center unit substations. This subject is particularly timely at present because of the widespread application of this equipment in vital war projects.

**42-86—Selenium Rectifiers and Principles of Their Design;** *John E. Yarmack (A '35). 25 cents by mail.* The purpose is to outline general principles of design of stacks, one or more of which make a rectifying unit. Starting with the availability of selenium plates or discs of various types, the engineer is confronted with the problem of (1) selecting the proper size of plate to provide the required d-c current output, (2) computing the required a-c voltage to be impressed on the rectifier stacks to give the necessary d-c output, and (3) analyzing various factors such as type of load, nature of service, and cost of selected rectifier. The paper includes dynamic and other characteristics of the principal sizes of selenium rectifier plates as applied to the design of single-phase, three-phase, full-wave, and half-wave rectifier units, and all varieties of loading. Typical circuits are analyzed and novel representative computations of rectifier units are included.

## Electrical Machinery

**42-75—Theory of the Brush-Shifting A-C Motor, Part III—Power-Factor Correction;** *A. G. Conrad (M '40), F. Zweig (Enrolled Student), J. G. Clarke (A '41). 20 cents by mail.* In the preceding papers of this series a method was described for determining the circle diagram and predicting the characteristics for the brush-shifting motor as it is used when the brushes are shifted to control speed. This paper extends the earlier work to show how the motor can be used to correct power factor. The range and limitations for this condition of operation are revealed from the circle diagram of the motor which has been developed and verified experimentally. Characteristics of the motor when used in this manner are presented.

**42-76—Theory of the Brush-Shifting A-C Motor, Part IV;** *A. G. Conrad (M '40), F. Zweig (Enrolled Student), J. G. Clarke (A '41). 20 cents by mail.* The preceding papers of this series presented an analysis

of the brush-shifting a-c motor. Parts I and II dealt with the case when the voltage introduced into the stator coils from the commutator was collinear with the voltage induced in the stator coils by slip. Part III dealt with the case when the voltage introduced into the stator coils from the commutator was in quadrature with the induced voltage. Part IV extends the earlier analysis to include all the possible phase positions of the voltage introduced into the stator coils from the commutator. Under these conditions power factor and speed are controlled simultaneously. Methods for constructing the circle diagram for these conditions are given, and the characteristics of the motor predicted from the circle diagram are compared with the characteristics obtained by laboratory tests.

**42-82—Temperature Aging Tests on Class A Insulated Fractional-Horsepower Motor Stators;** *J. A. Scott (M '34), B. H. Thompson. 15 cents by mail.* Temperature-aging data are presented on Class A insulated fractional-horsepower motor stators, determined at 200, 160, and 135 degrees centigrade, being a progress report on tests which will ultimately include data at 115 degrees centigrade. Such data are important in guiding ratings for motors which may be called on to operate for short periods at higher than normal temperatures. The data indicate that up to 200 degrees centigrade no abrupt change in the temperature-aging curve occurs. The slope of this curve indicates approximately that the time to failure is cut in half for an increase of 10 to 15 degrees centigrade in temperature.

**42-83—Rectifier Terminology and Circuit Analysis;** *C. H. Willis (F '42), C. C. Herskind (M '40). 15 cents by mail.* This paper presents a set of terms and definitions embracing the most important concepts arising in the rectifier field. The definitions are presented with the hope that they will help to clarify the existing confusion caused by the lack of an exact terminology and will be sufficiently useful to be widely adopted. The "reactance factor" is one of the newly defined terms which should be particularly useful in the analysis of rectifier circuits. This factor reduces the rectifier-circuit constants to a single per-unit quantity which may be entered as the independent variable in expressions giving the rectifier characteristics, such as voltage drop, power factor, harmonic voltages and currents, interphase voltages, etc. By its use the characteristics of any rectifier circuit, if expressed in per-unit values, may be reduced to a single set of characteristic curves, greatly simplifying the description and calculation of the operating conditions in the circuit. A list of formulas giving various rectifier characteristics in terms of "reactance factor" and a set of characteristic curves are included to illustrate the proposed method of analysis.

**42-84—Calorimetric Method for Determining Efficiencies of Electric Machines;** *Victor Siegfried (M '38), Charles W. Thulin (Application pending). 15 cents by mail.* Among the methods available for determining losses and efficiencies of electric machines, many have been developed to their utmost capabilities. Some measure individual losses separately and with good accuracy, but many have inherent drawbacks. There still remains the desirability of a satisfactory over-all test which will rate the performance of all sizes of machinery under actual conditions of loading and yet yield highly accurate results. This aim is largely met by the calorimetric method and is justified by its basic character. A simplification of the classical testing technique can be introduced in which the important measurements are all electrical. By this means, accurate measurements of heat values are obviated and the calorimeter becomes in reality only a comparator for substitution process. Test results of calorimetric measurements on small induction and d-c motors show excellent agreement with other tests on the same machines. Analysis of the method indicates that it is equally applicable to all classes of machines of any size, and that it can be used more generally for over-all loss and efficiency measurements under loaded conditions.

## Power Transmission and Distribution

**42-80—High-Voltage Fusing of Transformer Banks;** *H. H. Marsh, Jr. (M '41), G. B. Dodds (A '29). 15 cents by mail.* The paper summarizes some 15 years' experience with the high side fusing of 11-, 22-, and some 66-kv transformer banks. The original purpose of fusing has been expanded through this experience to cover functions that are deemed desirable, and the authors feel that their approach to the specific protection field served by fuses has resulted in satisfactory protection at minimum cost. The results of some faults occurring in fused and unfused banks are described briefly, and the various factors taken into consideration in selecting the proper fuse to use are discussed. The conclusions drawn are that fuses, when applicable, are a satisfactory economical means of obtaining reasonable coverage for faults in and beyond transformer banks.

# PERSONAL ....

**T. F. Barton** (A'12, F'30) district manager, General Electric Company, New York, N. Y., has been appointed commercial vice-president. He will continue as district manager. He was born in Orangeburg, S. C., December 25, 1885, and was graduated from the electrical engineering course of Clemson Agricultural College. In 1906 he was employed by the General Electric Company to do test and construction work, and in 1911 he was transferred to the engineering department of the company's New York office, in 1917 returning as section head to the central-station department, Schenectady. In 1927 he became district engineer of the New York district, in 1939 assistant manager, and in 1940, district manager. He is currently serving as a director of the Institute. **W. B. Clayton** (M'40) district manager, Dallas, Tex., also has been named a commercial vice-president. He was born April 7, 1888, Brooklyn, N. Y., and was graduated in 1905 from Alabama Polytechnic Institute with the degrees of bachelor of science in electrical engineering and in mechanical engineering. In 1905 he entered the testing department of the General Electric Company, Lynn, Mass., and in 1909 became an independent consulting electrical engineer. He returned to the General Electric Company, Dallas, Tex., in 1911 as meter specialist and has been with the company since that time, except for military service 1917–19. He was made central-station department manager of the southwest district in 1924, assistant district manager in 1928, and district manager in 1939. He will continue as district manager. **H. M. Towne** (A'24) central-station department, Pittsfield, Mass., has been appointed manager of sales for lightning arresters and fuse cutouts. He was born May 17, 1893, in Williamstown, Mass., and is a graduate of the General Electric test course. He became foreman of the lightning division, Pittsfield, Mass., in 1913, and in 1917 he joined the lightning arrester department to do commercial and design engineering. In 1929 he became a member of the transformer division, where he was connected with the sale of lightning-arrester equipment.

**F. E. Brooks** (A'38) chief engineer, Bronx-Westchester area, New York (N. Y.) Telephone Company, and **W. W. Truran** (A'23, M'30) chief engineer, Manhattan area, were appointed assistant vice-presidents recently when the Bronx-Westchester and Manhattan areas of the company were consolidated. Mr. Brooks was born January 27, 1890, in Kansas City, Mo., and received the degrees of bachelor of science in 1912 and electrical engineer in 1921 from the Case School of Applied Science. He entered the engineering department of the New York Telephone Company in 1912 and except for military service during 1917–19, has been with the company continuously. He was appointed engineer of plant extension, Bronx-Westchester area, in 1927, and in 1935 was given a similar position in the Manhattan area, his duties being extended in 1937 to include electrical engineering supervision of transmission design and maintenance. In 1939 he became chief engineer. Mr. Truran was born May 25, 1894, at Milbank, S. Dak., and received from the University of Wisconsin, the degree of bachelor of science in electrical engineering in 1917. He joined the New York Telephone Company in that year as assistant engineer, in 1925 was made engineer in charge of toll fundamental plans, and in 1928, general toll engineer. In 1940 he became chief engineer of the Long Island area, and in 1941 he was made

chief engineer of the Manhattan area. **B. K. Boyce** (A'10, F'41) vice-president and general manager, Bronx-Westchester area, has become chief engineer, Manhattan-Bronx-Westchester area. Born February 3, 1886, Little Valley, N. Y., he received the degree of electrical engineer from Cornell University in 1907 and in that year entered the employ of the New York Telephone Company. He was made transmission and plant extension engineer, upstate area, in 1925 and chief engineer, upstate area, in 1926. He became chief engineer, Manhattan area, in 1939, and vice-president in 1941.

**G. L. Knight** (A'11, F'17) assistant vice-president for shops and construction, Consolidated Edison Company of New York (N. Y.), Inc., and vice-president, Brooklyn (N. Y.) Edison Company, has retired. He was born February 20, 1878, at Haddonfield, N. J., and was graduated from the school of electrical engineering, Drexel Institute, in 1900. In that year he joined the Philadelphia (Pa.) Electric Company as switchboard operator, in 1901 became electrical draftsman, department of equipment, United States Navy Yard, New York, N. Y., and in 1902 mechanical draftsman for the New York Edison Company (later part of Consolidated Edison Company of New York) and manager, Walker Electric Company, Philadelphia, Pa. From 1903 to 1905 he was employed as chief draftsman, Waterside Station, New York Edison, and in 1905 he joined the Edison Illuminating Company of Brooklyn (later Brooklyn Edison Company) as chief draftsman. In 1908 he was appointed designing engineer and head of the engineering department, becoming mechanical engineer in 1923, and vice-president in charge of mechanical operations in 1932, in 1939 becoming vice-president and engineer of construction. He retained the position of vice-president of the Brooklyn company when he was appointed engineer of construction for Consolidated Edison in 1939 and assistant vice-president of construction and shops in 1941. He has served as a manager and vice-president of the AIEE, is a past president of the United Engineering Trustees, Inc., and a member of The American Society of Mechanical Engineers.

**C. A. Corney** (A'16, M'20) superintendent of engineering, Boston (Mass.) Edison Company, has been appointed assistant vice-president. He was born July 11, 1892, in Boston, Mass., and was graduated from Massachusetts Institute of Technology in 1914. He was employed as a laboratory instructor at Massachusetts Institute of Technology, Cambridge, during 1914–15, and in 1915 joined Stone and Webster, Inc., Boston, Mass. He has been associated with the Boston Edison Company and its predecessors for the past 20 years, having served as assistant superintendent from 1927 to 1937, when he became superintendent. **T. H. Haines** (A'23, M'31) superintendent, transmission and distribution, also has been appointed assistant vice-president. Born November 16, 1889, he was graduated from Massachusetts Institute of Technology in 1911, and after working as draftsman for the Sanitary Engineering Company and The Raymond Engineering Company, both of Boston, Mass., he joined the Boston Edison Company (then the Edison Electric Illuminating Company of Boston) in 1913 as assistant superintendent of the maintenance of lines. In 1925 he became superintendent.

**J. B. Fisken** (A'03, F'13) consulting engineer, Washington Water Power Company, Spokane, has retired. Born in Helensburgh, Scotland, November 2, 1861, he attended the College of Science and Arts, Glasgow, Scotland, and was graduated from the City and Guilds of London Institute. In 1886 he was employed by the Seattle (Wash.) Gas Company as superintendent. After being manager for the Victoria (B. C.) Electric Illuminating Company and doing electrical work for the Canadian Pacific Railway Company, Vancouver, B. C., he joined the Spokane Falls Electric Light and Power Company as superintendent in 1887, working for this company and its successor, the Edison Electric Illuminating Company, until 1895. He became superintendent for the Consumers Light and Power Company of Spokane (Wash.) in 1895, and in 1896 he was reappointed superintendent of the Edison Electric Illuminating Company, continuing in that capacity with its successor, the Washington Water Power Company. In 1918 he became chief engineer and in 1920 he was appointed consulting engineer. He was a manager of the Institute 1916–19 and vice-president 1919–20.

**R. R. Newquist** (A'40) district manager, sales department, Allis-Chalmers Manufacturing Company, Houston, Tex., has been appointed assistant to the vice-president. He was born November 14, 1905, at Youngwood, Pa., and was graduated from Pennsylvania State College in 1929 with the degree of electrical engineer. From 1929 to 1932 he was employed as sales engineer, Reliance Electrical and Engineering Company, Cleveland, Ohio, and during 1932–34 he was sales representative, Louis Allis Company, Chicago, Ill. In 1934 he joined the Allis-Chalmers company, Milwaukee, Wis., as sales representative. **C. W. Schweers** (A'37) sales engineer, New Orleans, La., succeeds him as district manager of the Houston office. He was born January 26, 1906, in San Antonio, Tex., and received the degree of bachelor of electrical engineering from Texas Agricultural and Mechanical College in 1929. He joined the Allis-Chalmers company in 1930 as student and sales engineer.

**L. W. Smith** (A'22, M'28) district engineer, Doble Engineering Company, Chicago, Ill., has been appointed vice-president. He was born December 5, 1890, at Patchogue, N. Y., and is a graduate of the engineering course of Pratt Institute. He entered the student engineering course of General Electric Company, Pittsfield, Mass., in 1911 and was transferred to the company's Schenectady plant in 1912. In 1915 he joined the Spier Falls plant of the Adirondack Power and Light Corporation as switchboard operator, and returned to the General Electric Company, Schenectady, in 1916 as switchboard proposal engineer, which position he held until 1920, except for an interval of military service 1917–19. He was district switchboard specialist at the Atlanta, Ga., plant 1920–22, and central-station engineer 1922–26. In 1926 he was employed as a consulting engineer by Sargent and Lundy, Chicago, Ill., and in 1933 he joined the Doble Engineering Company.

**H. B. Waters** (A'04) president and general manager, Telluride Power Company, Salt Lake City, Utah, has been appointed president and chairman of the board. Born July 19, 1879, he was graduated from Cornell University in 1903 with the degree of mechanical engineer. From 1903–05 he was with the Missouri River Power Company and from 1905–11 he was in charge of the mechanical and electrical departments, California Polytechnic School, San Luis Obispo. In 1911 he became chief engineer of the Beaver River Power Company and the Idaho Power and Light Company, Boise. During 1915–16 he was sales manager for the Idaho Power Company, and during 1916–17 general manager for the Beaver River Power Company and the Southern Utah Power Company. He was general manager of the Telluride company for over 20 years, becoming president in 1940.

**R. J. Wensley** (A'28, M'35) assistant general manager, I-T-E Circuit Breaker Company, Philadelphia, Pa., has been appointed general manager. He was born in Indianapolis, Ind., May 5, 1888. In 1903 he was employed as wireman by the Sanborn Electric Company, Indianapolis, Ind., and in 1909 joined the operating department of the Merchants Heat and Light Company, Indianapolis, Ind. From 1913 to 1916 he was assistant to the chief engineer, American Public Utilities Company, Grand Rapids, Mich. In 1916 he became section engineer, switchboard engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and in 1931 was transferred to the meter department of the company's Newark plant. In 1935 he joined the I-T-E Circuit Breaker Company as assistant general manager.

**W. R. C. Corson** (A'93) president and treasurer, Hartford (Conn.) Steam Boiler Inspection and Insurance Company, has become chairman of the board. He was born in New York, N. Y., February 18, 1870, and received the degree of bachelor of arts from Yale University in 1891. In that

year he entered the assembly and testing department of the Eddy Electrical Manufacturing Company, Windsor, Conn., and in 1892 was appointed assistant electrical engineer, later becoming superintendent and secretary. In 1902 he established a consulting engineering office in Hartford, Conn. He joined the Hartford Steam Boiler Inspection and Insurance Company as assistant engineer in 1907, was appointed assistant secretary in 1909, and secretary and treasurer in 1916. In 1921 he was made vice-president and treasurer, and in 1927 he was elected president.

**C. V. Aggers** (A'39) has been appointed manager of the X-ray division, Westinghouse Electric and Manufacturing Company, with headquarters at Baltimore, Md. Since 1940 he had been manager of engineering and manufacturing with the division which was formerly known as the Westinghouse X-Ray Company, Long Island City, N. Y. He was born September 3, 1905, at Franklin, Pa., and attended the University of Pittsburgh and Carnegie Institute of Technology. From 1925 to 1929 he was employed in the radio engineering department of the Westinghouse company, East Pittsburgh, Pa., and from 1929 to 1931 in the switchboard engineering department. He joined the supply engineering department in 1931 to work on radio interference problems. In 1934 he became control engineer, and in 1937, liaison engineer.

**C. M. Jansky, Jr.** (A'20, M'32) consulting engineer, Jansky and Bailey, Washington, D. C., has been appointed chief of the radio section of the War Production Board communications branch. He was born June 28, 1895, at Delton, Mich., and received from the University of Wisconsin the degrees of bachelor of arts and physics in 1917 and master of arts and physics in 1919. He was an instructor in physics, University of Wisconsin, Madison, during 1919–20, and in 1920 he joined the department of electrical engineering of the University of Minnesota, Minneapolis, as instructor, later becoming associate professor in charge of work on radio communication. In 1929 he established the consulting radio engineering firm, Jansky and Bailey.

**C. A. Bailey** (A'32) wire engineering department, **Charles Concordia** (A'31, M'37) central station engineering department, and **Gabriel Kron** (A'30) consulting engineer, engineering general department, all of General Electric Company, Schenectady, N. Y., have received 1941 Coffin awards for their outstanding contributions to the progress of the electrical arts. Other General Electric recipients were **L. E. Hildebrand** (M'21) electrical engineer, Lynn, Mass., **A. E. Anderson** (A'23, F'40) panel and equipment division, engineering section, Philadelphia, Pa., and **C. B. Wilson** (A'24) field engineer, New York, N. Y.

**P. H. Adams** (A'11, F'30) electrical engineer, electric engineering department, Public Service Electric and Gas Company, Newark, N. J., has been made consulting engineer of the department. He has been associated with the company since 1909. **M. D. Hooven, Jr.** (A'24, M'30) assistant transmission and substation engineer, has been appointed electrical engineer, electric engineering department. He joined the company in 1922.

**H. L. Wallau** (A'00, F'13) recently retired electrical engineer, Cleveland (Ohio) Electric Illuminating Company, has become principal electrical engineer, Aircraft Engineer Research Laboratory, Cleveland, Ohio. **Frederik Borch** (A'08, F'39) assistant electrical engineer, has been made electrical engineer of the Cleveland Electric Illuminating Company. He has been associated with the company since 1921.

**C. E. Mason** (A'34) general plant supervisor, Indiana Bell Telephone Company, Indianapolis, has been appointed division plant superintendent, outstate. He has been with the company since 1927. **E. K. Goss** (A'33) division plant superintendent, has become general plant supervisor. **A. E. Butler** (A'34) division plant superintendent, outstate, has been made division plant superintendent.

**William Kelly** (F'25) president, Buffalo, Niagara and Eastern Power Corporation, Buffalo, N. Y., has been awarded honorary membership by the American Society of Civil Engineers.

## OBITUARY • • • •

**Martin Hughes Gerry, Jr.** (A'93, M'96, F'13) consulting engineer, San Francisco, Calif., died December 30, 1941. He was born at Boston, Mass., October 16, 1868, and received from the University of Minnesota the degrees of bachelor of mechanical engineering in 1890 and bachelor of electrical engineering in 1891. In 1894 he received the degree of master of mechanical engineering from Cornell University. After doing electrical work for the Thomson-Houston Company and the Sprague Company during 1892–93, he joined the Metropolitan West Side Elevated Railroad Company, Chicago, Ill., in 1894. During 1898 he was employed as electrical engineer and superintendent of motive power, General Electric Company, Schenectady, N. Y., and was chief engineer and general manager of the Missouri River Power Company and the Helena Power Transmission Company from 1898 to 1912. He was consulting engineer for the Montana Power Company and maintained a general engineering practice until 1917, during which time he was engineer and manager, Montana Reservoir and Irrigation Company, and construction engineer on a number of power projects. During World War I, he was Federal Fuel Administrator for Montana, resuming his engineering practice after the war. He was later chief engineer in charge of water power and electric plants, St. Anthony Falls, Minneapolis, Minn., and since 1924 had been engaged in private engineering practice. He was active in developing methods of high-voltage transmission and improved hydroelectric practice. He was also a member of the American Society of Civil Engineers and Sigma XI.

**Alexander Cartwright Lanier** (A'04, M'14, F'39) professor of electrical engineering and chairman of the department of electrical engineering, University of Missouri, Columbia, died February 26, 1942. Born June 3, 1878, at Nashville, Tenn., he received from the University of Tennessee the degrees of bachelor of science in electrical engineering (1900) and mechanical engineer (1905) and that of master of electrical engineering from Harvard University in 1910. During 1900–02 he was associated with the General Electric Company, Lynn, Mass., and Schenectady, N. Y., in the testing department. From 1902 to 1905 he was instructor in mechanical engineering, University of Tennessee, Knoxville, and from 1905 to 1908 he was assistant professor of electrical engineering, University of Cincinnati (Ohio). In 1909 he entered the employ of Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., as design engineer and from 1911 to 1915 he was section engineer in charge of design of d-c generators and motors. In 1915 he was appointed professor of electrical engineering and chairman of the department of electrical engineering, University of Missouri. He was also a member of Sigma Xi, Tau Beta Pi, Eta Kappa Nu, and the Society for the Promotion of Engineering Education.

**Edward Walker Burbank** (A'25, M'30) district manager, industrial division, Allis-Chalmers Manufacturing Company, Dallas, Tex., died in April 1941. He was born February 15, 1889, at Sunbury, Ohio, and received the degrees of bachelor of electrical and mechanical engineering from Tulane University in 1911. He joined the Allis-Chalmers company, Milwaukee, Wis., in 1911 as a student apprentice and had been with the company since that time. From 1912 to 1913 he did electrical testing work, the following year he was draftsman in centrifugal pump design, and in 1914 he was engaged in estimating costs on hydroelectric machinery. He worked on testing and development of hydraulic equipment from 1914 to 1916, when he was appointed sales engineer in the New Orleans district office. He was transferred to the Dallas district office as district manager in 1921. He was also a member of The American Society of Mechanical Engineers.

**Carrol S. Plowman** (A'20) chief engineer, Waldrich Textile Company, Delawanna, N. J., died February 7, 1942. He was born at Fort Wayne, Ind., on October 24, 1887, and attended the Maryland Institute of Mechanical Engineering and Newark Technical School. From 1907 to 1910 he was assistant switchboard operator, United Electric Railway Company, Baltimore,

Md., and from 1910 to 1913 he held a similar position with the Edison Light and Power Company, York, Pa. In 1913 he became chief operator, Millville Manufacturing Company, Millville, N. J., leaving in 1916 to become watch engineer, Public Service at Marion Station, Jersey City, N. J. He joined the Singer Manufacturing Company, Elizabeth, N. J., as assistant chief operator in 1918, became chief operating engineer in 1928, and later chief engineer. He was appointed chief engineer of the Waldrich Textile Company in 1939.

**Ernest Wanamaker** (A'20) retired electrical engineer of the Chicago, Rock Island, and Pacific Railway Company, Chicago, Ill., died in August 1941. He was born November 15, 1880, at Bethany, Mo. He joined the Chicago, Burlington, and Quincy Railway Company in 1899 and later was engaged in railroad, mine, and mill construction work as a marine engineer. From 1907 to 1909 he served with the United States Reclamation Service and in 1910 he entered the employ of the Arnold Company, Chicago, Ill., as engineer and superintendent of construction. In 1913 he was appointed chief engineer for the Chicago, Rock Island, and Pacific company, and the following year he was made electrical engineer in charge of all electric lighting and power equipment, in 1939 becoming office electrical engineer.

**Daniel J. Mahaney** (A'34) plant supervisor, Southwestern Bell Telephone Company, Oklahoma City, Okla., died November 28, 1941. He was born February 17, 1896. From 1912–17 he was engaged in telephone work as outside plant engineer, following which he served in the United States Army. He was general engineering supervisor, Southwestern Bell Telephone Company, St. Louis, Mo., during 1924–25 and from 1926 to 1928 he was division plant engineer, Southwestern Bell company, Oklahoma City. In 1929 he was transferred to the Tulsa, Okla., plant as division construction superintendent, in 1931 was made district plant superintendent, and in 1932 became plant supervisor for the state of Oklahoma.

**Ray T. Wagner** (M'25) sales manager, lightning-arrester, cutout, and capacitor sections, General Electric Company, Pittsfield, Mass., died February 11, 1942. He was born August 17, 1883, at Delaware, Ohio, and received the degree of bachelor of science in electrical engineering from the University of Wisconsin in 1905. He had been associated with the General Electric Company since 1905, except for a year with the Alliance (Ohio) Gas and Electric Company, and had been in charge of lightning arrester sales since 1907. In 1929 he was transferred to the Pittsfield plant as sales manager. He was also a member of Tau Beta Pi.

**Robert John Strike** (A'04) city electrical engineer and superintendent of tramways, City of Launceton Corporation, Tasmania, died November 2, 1941. He was born at Plymouth, England, May 11, 1873, and attended Sydney Technical College. After serving as chief assistant at the electric light station, Broken Hill, New South Wales, Australia, he joined the Launceton Corporation as mains engineer and technical assistant in 1899 and later became chief engineer. He was also a member of the Institution of Electrical Engineers of Great Britain and the Electrical Association of New South Wales.

**Eugene Lucien Gibney** (M'40) supervising senior electrical engineer, lighting department, City of Seattle, Wash., died February 26, 1942. He was born in Butte, Mont., January 7, 1898, and was graduated from the University of Washington in 1922 with the degree of bachelor of science in electrical engineering. He had been employed in the lighting department of the city of Seattle since 1922, working as electrical draftsman until 1927 when he became relay engineer. He was appointed supervising senior engineer in 1939.

**Michael Yokich** (A'39) inspector, Signal Corps, United States War Department, specialty products division, Western Electric Company, Inc., Kearny, N. J., died February 12, 1942. He was born May 15, 1915, at Chisolm, Minn., and was graduated from the University of Minnesota with the degree of bachelor of electrical engineering. During 1938–39 he was employed as survey engineer, Northern Electric Cooperative Association, Virginia, Minn.

# MEMBERSHIP • •

## Recommended for Transfer

The board of examiners, at its meeting on March 19, 1942, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the national secretary.

**To Grade of Fellow**

Coover, M. S., professor and head of electrical engineering department, Iowa State College, Ames, Iowa.
Hodnette, J. K., engineering manager, transformer division, Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Teare, B. R., professor of electrical engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

3 to grade of Fellow

**To Grade of Member**

Bliesner, G. H., utilization representative, Bonneville Power Administration, Portland, Ore.
Bruncke, H. P., assistant electrical engineer, Northern States Power Company, Minneapolis, Minn.
Leitch, J. D., manager, development engineering department, Electric Controller and Manufacturing Company, Cleveland, Ohio.
Lightfoot, T. C., switchgear specialist, General Electric Company, New York, N. Y.
Miller, C. W., assistant engineer, New York and Queens Electric Light and Power Company, Flushing, N. Y.
Moses, M. G., planning engineer, Northern States Power Company, Minneapolis, Minn.
Pawlicki, E., electrical engineer, Defoe Boat and Motor Works, Bay City, Mich.
Simrall, H. C., assistant professor of electrical engineering, Mississippi State College, State College, Miss.
Sullivan, W. L., assistant professor, Stevens Institute of Technology, Hoboken, N. J.
Tellkamp, B. F., electrical engineer, Allen Bradley Company, Milwaukee, Wis.
Thomas, T. D., chief engineer, Texas Power and Light Company, Dallas, Tex.
Upham, W. A., general superintendent of distribution, The United Illuminating Company, New Haven, Conn.
Williams, E. A., in charge of switchgear device engineering, General Electric Company, Philadelphia, Pa.

13 to grade of Member

## Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical District. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before April 30, 1942, or June 30, 1942, if the applicant resides outside of the United States or Canada.

**United States and Canada**

1. North Eastern

Ailes, C., Jr., General Electric Company, Bridgeport, Conn.
Andrew, J. D., Jr., General Electric Company, Schenectady, N. Y.
Anthony, J. C., General Electric Company, Pittsfield, Mass.
Balsley, R. C., General Electric Company, Schenectady, N. Y.
Benjamin, J. E., General Electric Company, Pittsfield, Mass.
Bibber, G. W., Heald Machine Company, Worcester, Mass.
Bird, L. E., General Electric Company, Schenectady, N. Y.
Blaisdell, D., Allis-Chalmers Manufacturing Company, Boston, Mass.
Bonner, J., Jr., General Electric Company, Schenectady, N. Y.
Bost, T. F., Jr., General Electric Company, Schenectady, N. Y.
Bouldry, J. M., Holtzer-Cabot Electric Company, Boston, Mass.
Bowser, T. L. (Member), Stromberg-Carlson Telephone Manufacturing Company, Inc., Rochester, N. Y.
Brucker, G. W., General Electric Company, Schenectady, N. Y.
Burch, J. R., General Electric Company, Schenectady, N. Y.
Carabitses, N. L., American Electric Engineering Company, Boston, Mass.
Carson, D. B., General Electric Company, Schenectady, N. Y.
Chalberg, H. W. A., General Electric Company, Schenectady, N. Y.
Chamberlain, H. H., General Electric Company, Lynn, Mass.
Clark, E. C., General Electric Company, Schenectady, N. Y.
Cobb, E. N., Jr., General Electric Company, Schenectady, N. Y.
Coffin, J. H., General Electric Company, Schenectady, N. Y.
Coolidge, A. W., Jr., General Electric Company, Schenectady, N. Y.
Cunnare, F. H., United States Navy, Waltham, Mass.
Dann, E. H., General Electric Company, Schenectady, N. Y.
Day, L. N., General Electric Company, Schenectady, N. Y.
Decker, L. A., Norwalk Lock Company, South Norwalk, Conn.
Denyer, R. H., General Electric Company, Schenectady, N. Y.
Dye, R. H., General Electric Company, Schenectady, N. Y.
Erb, D. R., Hygrade Sylvania Corporation, Danvers, Mass.
Estabrook, C. G., United States Navy Underwater Sound Laboratory, Fort Trumble, New London, Conn.
Eusey, M. V., Jr., General Electric Company, Schenectady, N. Y.
Evans, W. R., General Electric Company, Schenectady, N. Y.
Feiker, G. E., Jr., General Electric Company, Schenectady, N. Y.
Folger, S. R., General Electric Company, Pittsfield, Mass.
Ford, L. C., General Electric Company, Schenectady, N. Y.
Forrester, J. W., Massachusetts Institute of Technology, Cambridge, Mass.
Franson, L. J. W., General Electric Company, Schenectady, N. Y.
Gahagan, W. S., General Electric Company, Schenectady, N. Y.
Greenaway, L. R., Hamilton Standard Propellers, East Hartford, Conn.
Griffin, J. J., General Electric Company, Schenectady, N. Y.
Griffin, R. C., General Electric Company, Pittsfield, Mass.
Gute, L. R., General Electric Company, Lynn, Mass.

Halstead, W. K., Massachusetts Institute of Technology, Cambridge, Mass.
Hamblett, M. F., Henschel Corporation, Amesbury, Mass.
Hartley, G. R., Jr., United States Army, 51st Armored Infantry, Pine Camp, N. Y.
Hasney, J. F., General Electric Company, Schenectady, N. Y.
Herrod, R. A., Jr., General Electric Company, Schenectady, N. Y.
Horbal, S., Narragansett Electric Company, Providence, R. I.
Hu, H. C., Trudeau, N. Y.
Innes, G. M., Brewer Titchener Corporation, Cortland, N. Y.
Jacob, D. M., General Electric Company, Schenectady, N. Y.
Kaste, V. E., General Electric Company, Schenectady, N. Y.
Kellogg, R. H., General Electric Company, Pittsfield, Mass.
Kuenning, R. W., General Electric Company, Schenectady, N. Y.
Lambert, J. B., General Electric Company, Schenectady, N. Y.
Leimontas, B. J., 502—26th Street, Niagara Falls, N. Y.
Lent, H. A., Hygrade Sylvania Corporation, Salem, Mass.
Lester, B. R., General Electric Company, Schenectady, N. Y.
Li, F. S., General Electric Company, Schenectady, N. Y.
Linke, E. A., General Electric Company, Schenectady, N. Y.
Lof, J. L. C., Massachusetts Institute of Technology, Cambridge, Mass.
Madden, R. M., General Electric Company, Pittsfield, Mass.
Marshall, J. F., Stromberg Carlson Telephone Manufacturing Company, Rochester, N. Y.
McAninch, O. G., General Electric Company, West Lynn, Mass.
Michelson, L. C., Gleason Works, Rochester, N. Y.
Mitch, J. E., Bendix Aviation Corporation, Sidney, N. Y.
Morack, M. M. (Member), General Electric Company, Schenectady, N. Y.
Mullen, J. W., General Electric Company, Schenectady, N. Y.
Mushrush, R. S., Jr., General Electric Company, Schenectady, N. Y.
Nagel, G. A., Connecticut State Highway, East Haddam, Conn.
Neiman, W. N., Jr., General Electric Company, Schenectady, N. Y.
Norrell, P. R., General Electric Company, Schenectady, N. Y.
O'Blenis, R., Maine Central Railroad Company, Waterville, Maine.
O'Connell, R. C., Boston Edison Company, Boston, Mass.
Ogle, H. M., General Electric Company, Schenectady, N. Y.
O'Keefe, B. J., General Electric Company, Lynn, Mass.
Parkinson, L. J., General Electric Company, Schenectady, N. Y.
Parsons, R. L., Jr., General Electric Company, Pittsfield, Mass.
Pellioni, A. F., General Electric Company, Schenectady, N. Y.
Pester, R. F., General Electric Company, Schenectady, N. Y.
Polisse, L. F., General Electric Company, Schenectady, N. Y.
Prim, R. C., 3rd, General Electric Company, Schenectady, N. Y.
Prince, D. C., Jr., General Electric Company, Schenectady, N. Y.
Raith, O. M., General Electric Company, Schenectady, N. Y.
Rankin, J. T., Portsmouth Navy Yard, Kittery, Maine.
Reese, E. B., General Electric Company, Schenectady, N. Y.
Rich, E. A., Western Massachusetts Companies, Greenfield, Mass.
Rohlfs, A. F., General Electric Company, Pittsfield, Mass.
Rosentreter, E. W., General Electric Company, Bridgeport, Conn.
Runkle, L. D., Raytheon Production Corporation, Newton, Mass.
Ryan, D. X., General Electric Company, Schenectady, N. Y.
Schlafly, H. J., Jr., General Electric Company, Schenectady, N. Y.
Schneider, G. R., Allis-Chalmers Manufacturing Company, Boston, Mass.
Schwanhausser, W. E., Jr., General Electric Company, West Lynn, Mass.
Schweers, O. H., General Electric Company, Bridgeport, Conn.
Settle, J. F., General Electric Company, Schenectady, N. Y.
Shackelford, L. C., General Electric Company, Lynn, Mass.
Shean, F. A., Jr., General Electric Company, Schenectady, N. Y.
Shelton, P. S., The Narragansett Electric Company, Providence, R. I.
Sibley, H. C., Jr., General Railway Signal Company, Rochester, N. Y.
Skelly, J. J., General Electric Company, Schenectady, N. Y.
Slaymaker, F. H., Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y.
Smart, W. R., General Electric Company, Schenectady, N. Y.
Stone, H. P., Connecticut Power Company, Stamford, Conn.
Temoshok, M., General Electric Company, Lynn, Mass.
Vahle, J., Jr., General Electric Company, Schenectady, N. Y.
Van Ryzin, P. D., Allis-Chalmers Manufacturing Company, Boston, Mass.
Walthers, E. R., General Electric Company, Schenectady, N. Y.
Waters, D. E., General Electric Company, Schenectady, N. Y.
Watters, R. L., General Electric Company, Schenectady, N. Y.
White, C. C., Jr., General Electric Company, Schenectady, N. Y.
Wollensack, F. E., Southern New England Telephone Company, New Haven, Conn.
Wood, F. B., Massachusetts Institute of Technology, Cambridge, Mass.
Ziegler, F. W., General Electric Company, Schenectady, N. Y.
Zimmermann, S. A., General Electric Company, Schenectady, N. Y.

2. Middle Eastern

Abrams, B. W., United States Naval Ordnance Laboratory, Washington, D. C.
Allsop, D. R., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Anderson, C. R., Chicago Pneumatic Tool Company, Cleveland, Ohio.
Austin, R. C., B. F. Goodrich Company, Akron, Ohio.
Barbi, J. L., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Barbrow, L. E., National Bureau of Standards, Washington, D. C.
Beacher, B. D., Westinghouse Electric Supply, Williamsport, Pa.
Bechtold, A. G., General Electric Company, Philadelphia, Pa.
Belsky, P., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Benavides, O. C., Westinghouse Electric and Manufacturing Company, Baltimore, Md.
Bender, T. D., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Bennetsen, W. J., RCA Manufacturing Company, Camden, N. J.
Berger, F. W., Bethlehem Steel Company, Sparrows Point, Md.
Berry, H. W., RCA Manufacturing Company, Camden, N. J.
Blair, N., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Boberg, R., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Bolljahn, J. T., Naval Research Laboratory, Washington, D. C.
Boyle, H. J., General Electric Company, Erie, Pa.
Brown, W. C., General Electric Company, Erie, Pa.
Buchanan, R. A., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Bucich, J., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Burks, A. W., University of Pennsylvania, Philadelphia, Pa.
Burrows, J. W., Naval Ordnance Laboratory, Washington, D. C.
Byrne, J. D., General Electric Company, Erie, Pa.
Casey, T. A., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Cole, B. R., RCA Manufacturing Company, Camden, N. J.
Coley, S. F., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Cooper, G. W., Line Material Company, Zanesville, Ohio
Cox, A. S., Jr., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Cox, N. R. (Member), Cramp Shipbuilding Company, Philadelphia, Pa.
Cummings, J. S., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Daly, E. J., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Danshaw, W., Industrial Collieries Corporation, Ellsworth, Pa.
Dieffenbach, A. P., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Dolan, A. J., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Ehrhardt, J. I., Reliance Electric and Engineering Company, Cleveland, Ohio.
Elley, A. G., New York Shipbuilding Corporation, Camden, N. J.
Englehart, F. A., Jr., Glenn L. Martin Company, Middle River, Md.
Entsminger, K., West Penn Power Company, Connellsville, Pa.
Essel, C. J., Navy Department, Washington, D. C.
Eubanks, K. W., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Evans, A. R., Naval Research Laboratories, Washington, D. C.
Farver, K. C., 801 West Clayton Street, New Castle, Pa.
Fisher, M. H., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Fiske, J. J., Jr., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Gallup, R. B., Rural Electrification Administration, Washington, D. C.
Ganther, J. R., Navy Yard, Washington, D. C.
Gilbert, W. H., David Taylor Model Basin, Carderock, Md.
Gilmour, A. R., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Goff, L. E., Jr., General Electric Company, Philadelphia, Pa.
Goldfarb, S., United States Navy, Washington, D. C.
Goldy, B. H., General Electric Company, Philadelphia, Pa.
Goostree, L. W., Jr., General Electric Company, Erie, Pa.
Gratian, J. W., Naval Ordnance Laboratory, Navy Yard, Washington, D. C.
Greene, D. E., Jr., Duquesne Light Company, Pittsburgh, Pa.
Harter, E. F., University of Pittsburgh, Pittsburgh, Pa.
Hartman, D. K., General Electric Company, Erie, Pa.
Haught, A. H., Celanese Corporation of America, Cumberland, Md.
Heck, A. C., Radio Station WPIC, Sharon, Pa.
Herpich, R. L., Union Switch and Signal Company, Swissvale, Pa.
Hester, E. L. (Member), The C. S. Bell Company, Hillsboro, Ohio.
Hines, C. S., West Penn Power Company, Kittanning, Pa.
Holmes, W. S., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Hunter, A., Jr., Cramp Shipbuilding Company, Philadelphia, Pa.
Johns, R. W., General Electric Company, Philadelphia, Pa.
Johnson, A. C., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Jones, A. W., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Jones, J. F. (Member), Consolidated Gas Electric Light and Power Company, Baltimore, Md.
Kuechle, J. D., General Electric Company, Philadelphia, Pa.
Lacy, E. E., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Lawhead, L. V., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Lester, J. B., War Department, Washington, D. C.
Levinson, N. M., Rural Electrification Administration, Washington, D. C.
Lindebeck, S. L., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Litman, B., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Loomis, C. A., Duquesne Light Company, Pittsburgh, Pa.
Lynch, D. S., Bendix Radio Division, Towson, Md.
Mac Lennan, A. G., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Madsen, W. C., Reliance Electric and Engineering Company, East Cleveland, Ohio.
Maursky, F. P., 3220 Lorain Avenue, Cleveland, Ohio.
McIlhenny, R. B., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
McKnight, M. N., Navy Department, Washington, D. C.
McLean, W. W., Princeton University, Princeton, N. J.
Milkis, M., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Moo, J. B., Westinghouse Electric and Manufacturing Company, Cleveland, Ohio.
Morris, H. R., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Morrison, H. L., RCA Manufacturing Company, Camden, N. J.
Muchmore, T. F. C., Philadelphia Electric Company, Philadelphia, Pa.
Musil, J. D., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Namey, A. E., Bendix Aviation Corporation, Philadelphia, Pa.
Needles, J. H., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Neuber, R. E., Owens-Illinois Glass Company, Toledo, Ohio.
Parrott, W. M., Chesapeake and Potomac Telephone Company, Washington, D. C.
Partlow, J. G., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Patten, R. B., RCA Manufacturing Company, Camden, N. J.
Patton, W. D., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Pease, N. H., Jr., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Perry, A. F., Delco Products Corporation, Dayton, Ohio.
Perry, N. W., General Electric Company, Erie, Pa.
Plunkert, J. F., United States Naval Air Station, Washington, D. C.
Posakony, P. R., RCA Manufacturing Company, Camden, N. J.
Potter, W. L., General Electric Company, Philadelphia, Pa.
Pugh, N. R., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Quade, E. A., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

Relis, M. J., Naval Ordnance Laboratory, Washington, D. C.
Rietz, E. B., General Electric Company, Philadelphia, Pa.
Rincliffe, R. G., Philadelphia Electric Company, Philadelphia, Pa.
Roberts, C. E., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Roumanis, P. J., General Electric Company, Philadelphia, Pa.
Sackett, W. T., Jr., Naval Ordnance Laboratory, Navy Yard, Washingtou, D. C.
Satterfield, O. D., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Schacht, E. L., War Department, Signal Corps, Philadelphia, Pa,
Shea, R. A., Signal Corps, War Department, Philadelphia, Pa.
Shealy, F. K., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Shuman, N., Philadelphia Electric Company, Philadelphia, Pa.
Sime, R. M., Chesapeake and Potomac Telephone Company, Washington, D. C.
Simpson, W. P., General Electric Company, Philadelphia, Pa.
Skoller, M., United States Army, Aircraft Radio Laboratory Wright Field, Dayton, Ohio.
Smith, N. A., Federal Machine and Welder Company, Warren, Ohio.
Smythe, A. C., United States Naval Reserve, Bureau of Ordnance, Washington, D. C.
Stene, E. L., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Stitt, C. B., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Stoltenberg, G. R., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Telford, J. M., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Tharp, N. B., Westinghouse Electric and Manufacturing Company, Baltimore, Md.
Tillotson, R. T., War Department, Washington, D. C.
Trefleisen, R. E., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Tuten, B. L., United States Naval Reserve, Washington, D. C.
Vanderpool, H. D., Signal Corps, United States Army, Dayton, Ohio.
Volgovskoy, B. (Associate re-election), Columbia Engineering Corporation, Cincinnati, Ohio.
Wagner, E. B., Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa.
Wagner, W. R., Carnegie-Illinois Steel Corporation, Duquesne, Pa.
Walther, M. F., B. F. Goodrich Company, Akron, Ohio.
Watson, R. P., General Electric Company, Erie, Pa.
Wax, N., Ohio State University, Columbus, Ohio.
Weiner, M. C., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Weisehan, R. F., Reliance Electric and Engineering Company, Cleveland, Ohio.
Wetmore, H. D. (Associate re-election), Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Weythman, V. E., Bureau of Aeronautics, Navy Department, Washington, D. C.
Williams, C. S., Jr., Rural Electrification Administration, Washington, D. C.
Wills, W. P. (Member), Brown Instrument Company, Philadelphia, Pa.
Witkin, E., United States Navy Yard, Philadelphia, Pa.
Zanzinger, G. W., Bendix Aviation Corporation, Philadelphia, Pa.
Zastrow, O. W., Rural Electrification Administration, Washington, D. C.

3. New York City

Alexander, H. J. (Member), Federal Power Commission, New York, N. Y.
Bailey, V. G., Western Electric Company, Kearny, N. J.
Beidler, S., War Department, Signal Corps, Belmar, N. J.
Bellingham, L. C., National Varnish Products Corporation, Woodbridge, N. J.
Berger, C. E. (Member), Hanson Van Winkle Munning Company, Matawan, N. J.
Bernstein, B. S., War Department, Radar Laboratories, Belmar, N. J.
Bisesi, J. L. (Member), Waugh Laboratories, New York, N. Y.
Bishop, W. M. (Member), Bell Telephone Laboratories, Inc., New York, N. Y.
Blumberg, H. G., United States Army, Signal Corps, Fort Monmouth, N. J.
Boehlen, C. F. J., International Telephone and Radio Manufacturing Corporation, E. Newark, N. J.
Bolz, C. A., Frederic R. Harris, Consulting Engineer, New York, N. Y.
Bostwick, M. A., Westinghouse Electric and Manufacturing Company, Newark, N. J.
Brett, R. E. (Member), Public Service Commission, New York, N. Y.
Buegler, J. A., Signal Corps Laboratories, United States Army, Fort Monmouth, Red Bank, N. J.
Cleckley, J. T., United States Army, Signal Corps, Fort Monmouth, Red Bank, N. J.
Clute, D. G., Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y.
Cobean, R. W., General Electric Company, Bloomfield, N. J.
Cohen, I. B., 355 East 165 Street, Bronx, New York, N. Y.
Dean, W. N., Sperry Gyroscope Company, Garden City, N. Y.
Doyle, R. L. (Member), New York Telephone Company, New York, N. Y.
Dwork, L. E., Navy Yard, New York, N. Y.
Erdman, H. G., Jr., Public Service Gas and Electric Company, Newark, N. J.
Feldman, K., The Lummus Company, New York, N. Y.
Frederick, W., Blue Network Company, Inc., New York, N. Y.
Guiles, C. H., Sperry Gyroscope Company, Garden City, N. Y.
Halligan, R. R., Western Electric Company, Bayonne, N. J.
Harrington, C. C. (Associate re-election), Mill and Factory, New York, N. Y.
Hasselbach, A. T., Department Water Supply, Gas and Electricity, New York, N. Y.
Hennessy, J. F. (Member), Kelly, Syska and Hennessy, New York, N. Y.
Holmboe, L. W., Westinghouse Lamp Division, Bloomfield, N. J.
Janis, P., RCA Manufacturing Company, Inc., Harrison, N. J.
Jensen, A. M., Western Union Telegraph Company, New York, N. Y.
Johnson, J. H., Signal Corps, Radar Laboratories, Belmar, N. J.
Jones, A. R., Westinghouse Electric and Manufacturing Company, Newark, N. J.
Jones, W. J., Signal Corps, Radar Laboratories, Belmar, N. J.
Keigher, B. J., Signal Corps General Development Laboratories, Fort Monmouth, Red Bank, N. J.
Kochenburger, R. J., Curtiss Wright Corporation, Caldwell, N. J.
Larkin, J. P., Electricoil Company, New York, N. Y.
Lindheimer, E. M., The Lummus Company, New York, N. Y.
Luk, Y. K., Ebasco Services Incorporated, New York, N. Y.
Maloney, T. E., Signal Corps Laboratories, Fort Monmouth, Red Bank, N. J.
McDougall, J. A., City Transit System, IRT Division, New York, N. Y.
Meyer, K. I., Sperry Gyroscope Company, Incorporated, Brooklyn, N. Y.
Miller, L., Newark Signal Corps Inspection District, Newark, N. J.
Mourey, M., Navy Yard, Brooklyn, N. Y.
Mulligan, J. A., Ward Leonard Electric Company, Mount Vernon, N. Y.
Nickerson, F. W., Guided Radio Corporation, New York, N. Y.
O'Donnell, D. J., Sperry Gyroscope Company, Inc., Brooklyn, N. Y.
Olson, V. A., Sperry Gyroscope Company, Incorporated, Brooklyn, N. Y.
O'Neill, E. F., Bell Telephone Laboratories, Incorporated, New York, N. Y.
Robinson, E. F., Foster Wheeler Corporation, New York, N. Y.
Russell, D. C., Sperry Gyroscope Company, Inc., Brooklyn, N. Y.
Sauberman, N. H. (Associate re-election), Third Naval District, New York, N. Y.
Schlomann, A. F., Public Service Electric and Gas Company, Newark, N. J.
Stachnik, V. A., Fredric R. Harris, Inc., New York, N. Y.
Stavrinedes, C., International Telephone and Radio Laboratories, New York, N. Y.
Stotz, C. C., Sperry Gyroscope Company, Inc., Garden City, N. Y.
Sugatt, R. H., Western Electric Company, Kearny, N. J.
Sullivan, M. R. (Member), American Telephone and Telegraph Company, New York, N. Y.
Thielz, W. H., International Telephone and Radio Laboratories, New York, N. Y.
Tideman, R., Public Service Eelectric and Gas Company, Newark, N. J.
Wilder, J. E., Western Electric Company, Kearny, N. J.
Wildfeuer, D., Gibbs and Hill, New York, N. Y.
Wilkerson, W. L., United States Army, Signal Corps, Fort Monmouth, N. J.
Wiszneauckas, G. R., United States Army, Signal Corps, Fort Monmouth, Red Bank, N. J.

4. Southern

Augustine, D. C., Jr., United States Engineers, Jacksonville, Fla.
Beeson, P. H., United States Army Air Corps, New Orleans, La.
Behr, I. F., Tennessee Valley Authority, Knoxville, Tenn.
Bell, J. S., Jr., Norfolk Navy Yard, Portsmouth, Va.
Crow, E. A., Jr., Tennessee Valley Authority, Gilbertsville, Ky.
Eflerson, R. R., Universal Exploration, Jefferson City, Tenn.
Goodloe, R. M., 764 Gillespie Street, Jackson, Miss.
Gosnell, R. E., Company F, 21st Engineers (Avn.), Langley Field, Va.
Green, G. B., Tennessee Valley Authority, Pickwick Dam, Tenn.
Hardy, R. G., Norfolk Navy Yard, Portsmouth, Va.
Koen, H. R., Jr., Georgia School of Technology, Atlanta, Ga.
Mauney, G. S., Tennessee Valley Authority, Wilson Dam, Ala.
Miller, M. F., National Advisory Committee for Aeronautics, Langley Field, Va.
Morrison, G. M., United States Army, E. R. T. C., Fort Belvoir, Va.
Newman, W. W., Jr., United States Army, Fort Jackson, S. C.
Pinker, J., Jr., Naval Proving Ground, Dahlgren, Va.
Price, R. C., Tennessee Valley Authority, Chattanooga, Tenn.
Pulley, R. L. (Member), Gulf Power Company, Pensacola, Fla.
Todd, F. C., Line Material Company, Memphis, Tenn.
Vickers, R., Westinghouse Electric and Manufacturing Company, Birmingham, Ala.
Walker, J. T. (Member), Appalachian Electric Power Company, Ivanhoe, Va.
Wilbanks, J. L., Jr., Tennessee Valley Authority, Knoxville, Tenn.
Williams, L. T., Georgia Power Company, Albany, Ga.
Wilson, S. B., E. I. DuPont de Nemours and Company, Waynesboro, Va.
Witt, R. B., Jr., Aluminum Company of America, Alcoa, Tenn.
Woodard, K. A., Tennessee Valley Authority, Wilson Dam, Ala.
Woodward, J. E., 122 Central Avenue, Greenville, S. C.
Wynn, R. S., Louisiana Polytechnic Institute, Ruston, La.
Zander, F. W., Jr., Florida Power Corporation, St. Petersburg, Fla.
Zirkuly, V., Tennessee Valley Authority, Chattanooga, Tenn.

5. Great Lakes

Allen, R. C., Commonwealth Edison Company, Chicago, Ill.
Anderson, J. W., Minneapolis-Honeywell Regulator Company, Minneapolis, Minn.
Austin, P. W., Peterson, Iowa.
Beck, G., Electrical Engineers' Equipment Company, Melrose Park, Ill.
Beitler, P. L. (Associate re-election), United States Navy, Allis-Chalmers Manufacturing Company, West Allis, Wis.
Bercovitz, N., Jr., Billings General Hospital, Fort Harrison, Ind.
Berger, O. R., Signal Supply Section, Quartermaster Depot, Chicago, Ill.
Bittner, D. R., Public Service Company of Northern Illinois, Chicago, Ill.
Black, W. E., Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
Buell, H. R., Bowling Green, Ind.
Cade, P. J., General Electric X-Ray Corporation, Chicago, Ill.
Clark, W. J., Western Electric Company, Chicago, Ill.
Coronin, L. D., Commonwealth and Southern Corporation, Jackson, Mich.
Demaree, F. E., Illinois Bell Telephone Company, Chicago, Ill.
DeStefano, R., Micro Switch Corporation, Freeport, Ill.
Durkee, C. E., Automatic Electric Company, Chicago, Ill.
Eckels, C. K., 8327 Kenyon Avenue, Wauwatosa, Wis.
Eckman, D. V., Allen-Bradley Company, Milwaukee, Wis.
Elliott, J. O., Zenith Radio Corporation, Chicago, Ill.
Fiedler, W. E., Western Electric Company, Chicago, Ill.
Finch, E. H., Northern States Power Company, Minneapolis, Minn.
Froland, L., Echo, Minn.
Gaudio, J. C., Zenith Radio Corporation, Chicago, Ill.
Gawura, S., Michigan Bell Telephone Company, Midland, Mich.
Gorton, E. D., Radio Station WKAR, East Lansing, Mich.
Hart, J. S., Jr., Allen-Bradley Company, Milwaukee, Wis.
Hendriks, H. J., Collins Radio Company, Cedar Rapids, Iowa.
Herrider, G. B., Jr., Automatic Transportation Company, Chicago, Ill.
Hetzler, L. R., General Motors Corporation, Milford, Mich.
Holz, P., Detroit Edison Company, Detroit, Mich.
Hugel, A., Public Service Company of Northern Illinois, Wheaton, Ill.
Hurd, F. D., Public Service Company of Northern Illinois, Chicago, Ill.
Johann, F. J., Electrical Engineers' Equipment Company, Melrose Park, Ill.
Johnson, J. F., General Electric Company, Fort Wayne, Ind.
Jones, R. W., Northwestern University, Evanston, Ill.
Kalb, R. M. (Member), Kellogg Switchboard and Supply Company, Chicago, Ill.
Kampschoer, J. F., American Telephone and Telegraph Company, Stevens Point, Wis.
Kean, W. F., Western Electric Company, Chicago, Ill.
Landgren, G. L., Public Service Company of Northern Illinois, Joliet, Ill.

Larson, E. W., ILG Electric Ventilating Company, Chicago, Ill.
Lewis, F. W., Allen-Bradley Company, Milwaukee, Wis.
Lindenberg, E. C., Globe Union Company, Inc., Milwaukee, Wis.
Lockwood, J. D., Jr., Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
Longley, R. H., Cutler-Hammer, Inc., Milwaukee, Wis.
Margeson, B. L., Allis-Chalmers Manufacturing Company, La Porte, Ind.
Markusen, D. L., Minneapolis Honeywell Regulator Company, Minneapolis, Minn.
Mathis, H. F., United States Navy, Chicago, Ill.
Matuska, J. W., Jr., General Chemical Company, River Rouge, Mich.
Maze, L., General Motors Corporation, La Grange, Ill.
Mika, H. S., Fairbanks, Morse and Company, Beloit, Wis.
Mock, C. J. (Member), Evans Products Company, Detroit, Mich.
Moore, C. R., Northern States Power Company, Minneapolis, Minn.
Nienaber, F. H., Jr., Zenith Radio Corporation, Chicago, Ill.
Risberg, A. C., Carnegie-Illinois Steel Corporation, Gary, Ind.
Robertson, G. D., General Electric Company, Fort Wayne, Ind.
Robidoux, L. J., Cutler-Hammer, Incorporated, Milwaukee, Wis.
Romano, J. (Associate re-election), Delta Star Electric Company, Chicago, Ill.
Sanders, S. R., P. R. Mallory Company, Inc., Indianapolis, Ind.
Sandora, V. C., International Business Machines Corporation, Detroit, Mich.
Schalla, M. M., Electro-Motive Corporation, La Grange, Ill.
Schmitz, K. L., Western Electric Company, Inc., Chicago, Ill.
Schroeder, C. F., Carnegie-Illinois Steel Company, Chicago, Ill.
Scott, D. H., Iowa Electric Light and Power Company, Cedar Rapids, Iowa.
Shapiro, D. L., Western Electric Manufacturing Company, Hawthorne Station, Ill.
Shulman, A., Wells-Gardner and Company, Chicago, Ill.
Stamm, J. S., Sciaky Bros., Chicago, Ill.
Stancl, W. E., Carnegie-Illinois Steel Corporation, Chicago, Ill.
Talcott, H. C., Automatic Electric Company, Chicago, Ill.
Talty, T. E., 4712 North Paulina Street, Chicago, Ill.
Tornquist, E. L. (Member), Public Service Company of Northern Illinois, Chicago, Ill.
Ungrodt, R. J., Allis-Chalmers Manufacturing Company, West Allis, Wis.
Vater, R. F., Line Material Company, South Milwaukee, Wis.
Waychus, F. J., Illinois Bell Telephone Company, Gary, Ind.
Wilson, C. A., Indianapolis Power and Light Company, Indianapolis, Ind.
Winget, W. F., Public Service Company of Northern Illinois, Waukegan, Ill.
Witts, S. N. (Member), Northern State Power Company, Minneapolis, Minn.
Yost, K. E., Zenith Radio Corporation, Chicago, Ill.
Zych, N. E., Universal Unit Power Shovel Corporation, So. Milwaukee, Wis.

6. North Central

Austin, T. M. (Associate re-election), United States Bureau of Reclamation, Denver, Colo.
Wilson, J. E., Colorado Central Power Company, Englewood, Colo.

7. South West

Adams, J. L., Union Electric Company of Missouri, St. Louis, Mo.
Arnold, W. F., United States Army, Fort Riley, Kans.
Barfield, J. E. (Member), St. Joseph Railway, Light, Heat and Power Company, St. Joseph, Mo.
Blackman, B. A., Weleetka, Okla.
Butterfield, F. E., Jr., Wagner Electric Corporation, St. Louis, Mo.
Campbell, C. D., Humble Pipe Line Company, Houston, Tex.
Copmann, C. J., Jr., United States Army, Corps of Engineers, Fort Leonard Wood, Mo.
Davis, J. G., Southwestern Bell Telephone Company, Oklahoma City, Okla.
Geisen, H., Union Electric Company of Missouri, St. Louis, Mo.
Geldhof, A. R., Halliburton Oil Well Cementing Company, Duncan, Okla.
Granberry H. W., General Electric Company, Dallas, Tex.
Head, F. E., Monsanto Chemical Company, St. Louis, Mo.
Kastl, F. J., United States Army, Camp Bowie, Tex.
Latshaw, R. E., Giffels and Vallet, St. Louis, Mo.
Lehman, C. H. (Member), Westinghouse Electric and Manufacturing Company, San Antonio, Tex.
Lewallen, T. M., United States Engineer Office, Little Rock, Ark.
Marquardt, W. G., Texas Electric Service Company, Eastland, Tex.
Martin, L. F., Union Electric Company, St. Louis, Mo.
McLane, F., Box 402, Mercedes, Tex.
Murray, J. E., Delta-Star Electric Company, Wichita, Kans.
Stephenson, R. E., United States Field Artillery, Fort Sill, Okla.
Swallow, E. L., General Electric Company, St. Louis, Mo.
Williams, R. L., Jr., Westinghouse Electric and Manufacturing Company, St. Louis, Mo.

8. Pacific

Abbey, K., San Diego Gas and Electric Company, San Diego, Calif.
Andreae, S. C. (Associate re-election), Consolidated Steel Corporation, Wilmington, Calif.
Austin, W. F., United States Army Airbase, Minter Field, Bakersfield, Calif.
Bull, R. W., Sterling Electric Motors, Incorporated, Los Angeles, Calif.
Corrao, J., Department of Public Works, San Francisco, Calif.
Elliot, T. S. (Member), Leeds, Hill, Barnard and Jewett, Santa Maria, Calif.
Evestone, S. F., United States Army, Signal Corps, Los Angeles, Calif.
Folks, J. C., Bethlehem Steel Company, Terminal Island, Calif.
Gillings, J. W., 924 West 37th Street, Los Angeles, Calif.
Gjesdahl, D. J., Aluminum Company of America, Los Angeles, Calif.
Herman, F. F., Douglas Aircraft Company, Santa Monica, Calif.
Hitchcock, C. E., Joslyn and Ryan, San Francisco, Calif.
Jandt, H. A., Allis-Chalmers Manufacturing Company, Los Angeles, Calif.
Jensen, D. R., United States Army, Benicia Arsenal, Benicia, Calif.
McGeever, J. T., United States Army, Company A, 81st Infantry Training Battalion, Camp Roberts, Calif.
McNaughton, J. F., Naval Training School, Treasure Island, San Francisco, Calif.
Morrison, C. R., Naval Air Station, Alameda, Calif.
Moulthrop, R. A., Pacific Gas and Electric Company, Oakland, Calif.
Mueller, E. H., RCA Communications, Inc., Bolines, Calif.
Oflermann, P. F., United States Army, Fort Ord, Calif.
Poppino, C. A. (Associate re-election), General Electric Company, Phoenix, Ariz.
Quinley, J. E., Douglas Aircraft Company, Inc., Santa Monica, Calif.
Sandusky, R. C., Lockheed Aircraft Company, Burbank, Calif.
Schmidt, R. B., United States Army, Signal Corps, Fort Bragg, Calif.
Schultz, A. W., Westinghouse Electric and Manufacturing Company, Emeryville, Calif.
Shearer, R. W., Jr., Boeing School of Aeronautics, Oakland Airport, Calif.
Snitzer, T. L., Douglas Aircraft Company, Santa Monica, Calif.
Taylor, F. H., American Potash and Chemical Corporation, Trona, Calif.
Wagner, W. J., California Institute of Technology, Pasadena, Calif.
Wilson, G. A., American Forge Company, Berkeley, Calif.

9. North West

Arndt, E. W., Puget Sound Power and Light Company, Seattle, Wash.
Chesebro, E. L., Puget Sound Navy Yard, Bremerton, Wash.
Elliott, R. G., Pacific Telephone and Telegraph Company, Seattle, Wash.
Gilbert, C. M., Puget Sound Power and Light Company, Seattle, Wash.
Hamill, G. R., Washington Water Power Company, Spokane, Wash.
Harriott, L. C., Corps of Engineers, United States Army, Fort Lewis, Wash.
Jacobsen, A. B., University of Washington, Seattle, Wash.
Kirkman, W. L. (Associate re-election), Bonneville Power Administration, Portland, Ore.
Kuvallis, J. N., National Defense School, Portland, Ore.
Larson, C. V., Seattle-Tacoma Shipbuilding Corporation, Seattle, Wash.
Licwinko, L. S., Seattle-Tacoma Shipbuilding Corporation, Seattle, Wash.
Rogers, E. J., Bonneville Power Administration, Portland, Ore.
Smedstad, H. M., Puget Sound Power and Light Company, Everett, Wash.
Snow, W. C. (Member re-election), City Lighting Department, Seattle, Wash.
Spendlove, M. J., United States Bureau of Mines, Salt Lake City, Utah.
Stanley, M. G., Puget Sound Power and Light Company, Seattle, Wash.
Toman, G. W., Bonneville Power Administration, Portland, Ore.
Winter, B. J., Boeing Aircraft Company, Seattle, Wash.
Yeates, J. A., Jr., United States Engineer Department, Fort Beck, Mont.

10. Canada

Barchyn, D. E., Canadian General Electric Company, Peterboro, Ont.
Clink, A. R., Canadian Westinghouse Company, Limited, Hamilton, Ont.
Cole, D. L., Canadian General Electric Company, Peterboro, Ont., Can.
Creighton, H. H. L., Canadian General Electric Company Ltd., Peterboro, Ont.
Diak, V. W., Canadian Controllers Limited, Toronto, Ont.
Foster, J. M., Canadian General Electric Company Ltd., Peterborough, Ont.
Lorenzen, I. (Member), Packard Electric Company, Limited, St. Catharines, Ont., Can.
Loughty, W. B., Boiler Inspection and Insurance Company, Toronto, Ont.
MacInnes, T. M., National Research Council, Ottawa, Ont.
Mark, W., Canadian Engineering Standards Association, Toronto, Ont.
Monasch, L. B., University of British Columbia, Vancouver, B. C.
Morin, D. P., Powell River Company, Ltd., Powell River, B. C.
Nathanson, M. (Associate re-election), Canadian Armature Works, Montreal, Quebec.
Phillips, S. C., Canadian General Electric Company, Peterboro, Ont.
Rollefson, J. A. K., Canadian Industries, Limited, Shawinigan Falls, Quebec.
Ryder, C. V., Canadian Westinghouse Company, Hamilton, Ont.
Squires, F. H., University of Toronto, Toronto, Ont.
Wirtanen, E. W., 337 Dunedin Street, Victoria, B. C.

Total, United States and Canada, 524

**Elsewhere**

Blanco, A., Jr., Companía Comercial Trinsuco, S. A., Habana, Cuba.
Huizi, A., Lago Petroleum Corporation, Maracaibo, Venezuela, S. A.
Kilduff, W. C., United States Army, Fort Mills, Philippine Islands.
McFadden, G. E., Jr., Panama Canal, Diablo Heights, C. Z.
Molstrom, H. V., Ericsson Telephone Company, Mexico, D. F.
Readyhough, H. L. (Member), The Gourepore Electric Supply Company, Limited, Naihati, E. B. Ry., India.
Rivera, F. A. G., United States Army, 65th Infantry, Fort Buchanan, P. R.
Stuart, W. T., Ketchikan Public Utilities, Ketchikan, Alaska.

Total, eleswhere, 8

## Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the addresses as they now appear on the Institute record. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Accioly, Pompeu Barbosa, Caixa Postal 571, Rio de Janeiro, Brazil, S. A.
Andreasen, Ingwald A., 230—75th St., Brooklyn, N. Y.
Butler, N. O., Route 1, Moore, Okla.
Butler, Oliver D., 1355 E. 47th Place, Chicago, Ill.
Daily, Charles S., Jr., 1723 Eye St., N. W., Washington, D. C.
de Bonneval, Henri, Sigma Place, Riverdale, N. Y.
Dennis, Roman, Jr., 360 Amherst St., Buffalo, N. Y.
DeWestfelt, Gerard P., 1211 York Ave., New York, N.Y.
Evans, T. C., Jr. 160—16th Ave., N. W., Washington, D. C.
Fager, C. R., 1500 Spruce St., Berkeley, Calif.
Farmer, Lee Linzey, Balboa Heights, C. Z.
Hafely, Charles Harold, 715 W. Maumee, Angola, Ind.
Hilt, William Myron, 30 W. Chicago Ave., Chicago, Ill.
Innis, Harry H., 5325 Forbes St., Pittsburgh, Pa.
Jackson, Boris Anton, 54 Wendell Ave., Pittsfield, Mass.
Kettering, Clifford C., 403 Westminster, Los Angeles, Calif.
Klein, William, 219 Echo Place, New York, N. Y.
Krzemien, August, Childs Co., 570 Lexington Ave., New York, N. Y.
Levy, Harold C., 1523 Stone, Great Bend, Kans.
Lofstrand, A. L., Box 5043, Quarry Heights, C. Z.
McConnell, Malcolm E., 5424—5th Ave., Pittsburgh, Pa.
Monks, W. E., 837—22nd St., N. W., Washington, D. C.
Montgomery, W. E., 401 S. Electric, Alhambra, Calif.
Moore, W. H., 600 Braxton Place, Alexandria, Va.
Nungester, Jay L., 930 S. Lincoln, Spokane, Wash.
Roberts, C. F., Jr., Houston Lighting & Power Co., Engg. Dept., Box 1700, Houston, Texas.
Schrawder, Robert Rat, 606 Pine St., Lancaster, Pa.
Smith, Henry A., 4232 Baring Ave., East Chicago, Ind.
Steidinger, Dean K., 265 Fairmont Ave., Hyde Park, Boston, Mass.
Taylor, Richard V., 1825 G St., N. W., Washington, D. C.
Warriner, Robert R., 4251 W. Irving Park Road, Chicago, Ill.
Whitescarver, Robert S., 400 Center St., Wilkinsburg, Pa.
Wirpio, Carl I., 1000 Central Ave., Louisville, Ky.

33 Addresses Wanted

## Navy Announces Training Program in Collaboration With Colleges

The United States Navy has announced a new educational program that is intended on the one hand to keep young men in college to the limit of their ability, and on the other hand to provide the Navy with 80,000 or more specially trained young men per year qualified for advanced ratings or commissions. This program is available to any recognized university or college willing to effect only slight modifications in its regular undergraduate curricula to emphasize physical training, science, and mathematics, and will be administered by the school. Eligible candidates are young men between 17 and 19 years of age who have graduated from high school and entered—or been accepted for entrance to—any college or university collaborating with the Navy in the educational program. The students will carry on their college work at their own expense and will be allowed to continue it as far as they can do so within quality limitations prescribed by the Navy, after which they will be taken into active service at ratings in accord with their degree of advancement. It is an American plan for red-blooded American manhood and for educational institutions seriously interested in performing a vital service in an American way.

The announcement was made in Chicago February 21, 1942, by AIEE Vice-President J. W. Barker, special assistant to the Assistant Secretary of the Navy and dean of engineering at Columbia University. The occasion was a conference of presidents, deans, and other representatives of 125 colleges and universities, sponsored by the Institute of Military Affairs at the University of Chicago. The substance of Doctor Barker's announcement is given in the following paragraphs.

### BARKER EXPLAINS PROGRAM

The Navy believes in education, is itself an educational institution, and wants to support all proper and desirable educational work. It is recognized that the continuance of the democratic principles for which this war is being fought will depend in the long run upon the institutions of higher education continuing to train the youth of this nation who will be the leaders in the postwar reconstruction. The Navy's fundamental policy is to disrupt as little as possible the higher educational processes of the country.

College laboratories and classrooms are the training grounds where Navy officer and higher-rated enlisted personnel secure their preliminary general training for that leadership which is so vitally necessary. The length of time it will take our Army and Navy to train the officer and enlisted personnel to man and to fight this war will depend largely upon the quality of the physical, mental, and spiritual training given to young people in the secondary schools and in the colleges and universities. Nothing is more shocking than the percentage of rejections for physical disability that have been disclosed in military examinations. As a nation we have become extremely soft; we neglect our physical condition; we don't exercise; we don't remedy our defects; our school system has paid only lip service to physical training. To make up for this failure, both Army and Navy have had to take precious time to build up the physical fitness of their men before real military and naval training could be begun. The gravity of the present war situation already indicates that this is not going to be a short war, easily won without great sacrifices on the part of all. The Navy dare not plan on anything less than the long pull.

Among the democratic principles for which the current war is being fought are the academic freedom of our educational institutions, and the right of the individual to a choice of occupation so long as the safety of the nation permits. The receipt of a grant of freedom always imposes an obligation on the recipient—an obligation to support and defend the source from which the grant was received. The academic freedom of our institutions means that they owe a duty to offer minor modifications of curricula calculated to prepare students to meet urgent and pressing demands now facing them. Similarly the right of the individual to a choice of lawful occupation also involves the obligation to train himself and to improve his capacity to serve in that occupation where and when needed.

The most urgent and most pressing need at the present time is for man power in three capacities—Army, Navy, and war industry. At present, the Navy needs enlisted men at the rate of about 250,000 per year, aviation cadets at the rate of at least 30,000 per year, and reserve officer candidates to the total of approximately 11,000 per year.

To meet the bulk of these needs, the Navy offers, and will continue to offer through its regular recruiting service, voluntary general service enlistments in both the regular Navy and the Naval Reserve to those of good moral character who can meet the enlisted physical standards and who can pass the prescribed intelligence test. Such recruits are sent to Naval Training Stations, of which there are several. The Navy offers these men opportunities to attend its own vocational schools in electrical, ordnance, clerical, communications, hospital corps, machinist, metal workers, woodworkers, aviation mechanic, and aviation metalsmith. Needs for these specialties are met from among the vocational school students who demonstrate the highest aptitude. The remainder go to the Fleet for additional service training.

### 80,000 STUDENTS TO GET CHANCE

The new extension of the Navy's personnel recruitment plan is aimed toward providing for technically skilled men and well-trained officer candidates, and is directly applicable to those young men now freshmen or sophomores in accredited colleges or about to enter such colleges. From this group the Navy will accept voluntary enlistments as Apprentice Seamen (V-1) of not more than 80,000 men per year who are between the ages of 17 and 19 years inclusive, who are of good moral character, who can meet the enlisted physical examination standards, and who will complete in college at their own expense the Navy Department's accepted preinduction training curricula, on an inactive status for the equivalent of the first two calendar years. The preinduction Naval training curricula will be prepared by the faculty of any accredited college which desires to participate in this plan, and will conform to the normal program of that college provided such normal program properly stresses physical training, mathematics, and the physical sciences. The Navy Department through its Bureau of Navigation, Division of Training, will consult with colleges desiring to participate and will assist and advise on curricula. Courses will be given by regular faculty members, as there is no intention or desire on the part of the Navy to militarize instruction.

The Navy emphasizes the fact that this plan is in no way a resurrection of the Student Army Training Corps of the First World War. It is purely preinduction training given *by* the regular college or university faculties, *at* their own institutions, *to* those students who manifest a desire to take such instruction by voluntarily enlisting in the Navy in Class V-1. When a V-1 man completes, with academic grades satisfactory to the school, approximately $1^1/_2$ calendar years of his college work on that school's accepted program, he will take a comprehensive general examination of the "objective type," prepared by the Navy Department.

### VARIETY OF OPPORTUNITIES

If the student ranks sufficiently high in the comprehensive examination and *volunteers* for aviation cadet (Class V-5) flying training, and has improved his physical fitness sufficiently to meet the Naval Aviation physical standards, he will (up to a total of about 20,000 per year) be permitted to finish at least two calendar years at college before being transferred to the V-5 program for training to be officer-pilot.

From among the V-1 men ranking sufficiently high in the comprehensive examination, and volunteering for general deck or engineering duty training, and who have improved their physical fitness to meet the officer physical examination standards, up to 15,000 per year will be selected and transferred from V-1 to V-7 enlistment. In this latter status they will be continued on inactive duty and permitted to continue on their regular engineering school or college programs acceptable to the Navy Department to the baccalaureate degree as prescribed by the college, so long as such students maintain academic standards satisfactory to the faculty, and as long as the exigencies of the war permit. Of these 15,000 V-7 apprentice seamen, approximately 5,000 will be accepted from standard engineering courses and the remainder from programs acceptable to the Navy Department. On completion of their college work, the entire number will be given Reserve Midshipmen training leading to a commission as Ensign D-V (G), E-V (G) or in the specialist grades for which they are particularly qualified.

The balance of the V-1 men, who do not pass the comprehensive examination with grades high enough to permit them to exercise either of the foregoing two choices, will be permitted to finish two calendar years of the preinduction training program of the college and then called to active duty as Apprentice Seamen. Any man in the V-1 group who fails to achieve passing grade in the subjects of the school's approved preinduction training program, will be called to active duty, sent to a Naval Training Station, and processed just as is the general service enlistee.

Under the newly announced plan, every accredited institution of higher education in the United States is privileged, if it so desires, to participate actively as an integral part of Navy training on a *nonmilitarized* preinduction program for those of its students who desire to enter the Navy. The program is based upon solid democratic principles. It does not put the men in college into uniform, nor does it require Naval drill.

### SOUND TRAINING FOR MODERN LIFE

The program suggests minor redirection of the college's normal program of studies, but this redirection is toward a sound and solid preparation for life, work, and leadership in a mechanistic civilization. During the two-year preinduction training period the program will lay a firm mathematical and physical-science background upon which regular college faculties can build the upper two years of collegiate training toward whatever field of peacetime endeavor the student hopes to enter, whether he continues in college now or returns to college after he has served his country.

The Navy believes that the same collegiate training as will basically prepare men for effective service in this war is also the basic training for leadership in peacetime civilian pursuits. Therefore, the Navy believes that proper voluntary preinduction training for the Navy by regular accredited educational institutions and at regular accredited institutions also is excellent training for civilian pursuits in the work of the nation.

The new program will not interfere in any way with the several established avenues to Naval commission for those who desire to become permanent officers of the Navy and to make Naval work their life career. Neither will there be any change in the present Naval Reserve Officers Training Corps program. As supplemented by the new program, there are now the following eight avenues to a commission in the Navy:

1. Graduation from the Naval Academy for permanent officers.
2. Commission directly from civil life of experts in the specialist type of commission, such as A-V (S), O-V (S), CEC-V (S), etc.
3. Naval ROTC graduation.
4. V-1 enlistment and selective volunteering for V-5 aviation cadet training as outlined in preceding paragraphs.
5. V-1 enlistment and selective volunteering for V-7 training as outlined in preceding paragraphs.
6. V-1 and general service enlistment, active duty as enlisted man, competition for Naval Academy Preparatory course, competitive examination for Naval Academy appointment and graduation from Annapolis as in item 1 of this group.
7. V-1 or general service enlistment, recommendation by his commanding officer and selection to take training as aviation cadet (V-5) or reserve midshipman (V-7) with commission as reserve officer upon completion.
8. Promotion from Warrant Officer grade.

While it is not explicitly stated in Doctor Barker's address nor in the booklet of information on the V-1 program issued by the Navy Department, it must be obvious that those men who are called to active duty as enlisted men after the benefits of two calendar years of collegiate work will have most excellent opportunities to qualify for "ratings" in the many classifications needed in a highly mechanized Navy. This should make the program particularly attractive to all students.

### FULL INFORMATION AVAILABLE

With reference to the matter of redirecting the emphasis in existing curricula, faculties of interested colleges are entirely at liberty to submit any suggestions to the Training Division of the Bureau of Navigation for comment and advice. The Navy has no desire to "regiment" educational programs; it will not prescribe any program; it will only advise on and finally approve or disapprove the adequacy of curricula suggested by any interested school. The Navy believes thoroughly that a variety of programs is desirable.

Special arrangements have been made to handle the cases of present freshmen and sophomores in accredited colleges who desire to enlist in this V-1 program.

The Navy Department has issued a booklet "Information for Institutions of Higher Education as to Class V-1, U. S. Navy (accredited college program)," copies of which can be obtained upon request to Training Division, Bureau of Navigation, Navy Department, Washington, D. C.

# Educators at Chicago Conference Discuss Premilitary Training

To discuss ways and means whereby colleges and universities may most effectively serve the needs of the nation in its present war efforts, presidents, deans, and other representatives of some 125 such institutions gathered for a conference February 21, 1942, under the sponsorship of the Institute of Military Affairs at the University of Chicago. In general, the program of the conference consisted of (*a*) a report and consideration of the activities and points of view of several universities, (*b*) addresses and recommendations given by representatives of the training divisions of the Army and the Navy, and (*c*) consideration of various suggested plans of procedure for more or less special collegiate work directed toward meeting military needs. The conference utimately adopted resolutions endorsing a co-operative program presented and explained by Doctor J. W. Barker, special assistant to the Assistant Secretary of the Navy, the essential details of which plan are given elsewhere in these pages.

### COLLEGE VIEWS AND ACTIVITIES

In a prepared paper, President Ernest H. Wilkins of Oberlin College reported upon the results of a questionnaire sent by that school to its previous students now in military service. The questionnaire read:

"We are of the opinion that there might be devised some kind of special course for men who will soon be in the service that would fit them as well as possible for the physical and psychological experience they will have after they go into training. If you were in my place, but had the background of your own camp experience, what elements would you recommend putting into such a course?"

Essentially all responses to this questionnaire emphasized the military value of a liberal education, the importance of a rigorous physical-education program including broad individual participation in sports, the importance of a broad knowledge of the physical sciences, and the essential need for an understanding of discipline and the knowledge of how to participate in a highly disciplined undertaking. There was a dour warning against quasi-military drill. The essential substance of President Wilkins' recommendations may be summarized as follows: That it is the duty of a university in the present crisis (*a*) to maintain liberal arts curricula unimpaired, but to modify certain courses the better to relate them more specifically to war needs;

(*b*) to provide guidance as to what courses are valuable as basic preparation for later military training, and in this guidance to emphasize the importance and necessity of mathematics and the physical sciences; (*c*) to speed up the educational processes through *intensification* of work and *not* through short cuts; (*d*) to provide instruction in care of the body, including first aid and hygiene, and to give physical examinations and thoroughgoing corrective action not only through gymnastic exercises but also through medical and surgical care as required; (*e*) to limit any attempt of premilitary indoctrination to a one-term course for men just before they are called into service, to limit such course to basic fundamentals, and to maintain carefully the accuracy of the instructions given.

The general tenor of discussion indicated that most universities are actually speeding up their educational procedures in one way or another; also that many have developed an elaborate and superficial facade of special courses, or frequently special names for regular courses, setting up what commentators called a "glamour program" as compared with the solid and very practical collegiate education foundation sought by military and naval authorities. Some schools, worried about a prospective decline in student enrollment, have sought to promote the establishment of a special military classification which through government subsidies would attract people long out of school to return for prescribed special courses.

The point of view of the Army was presented by Colonel B. W. Venable of the Training Division of the General Staff. On behalf of the War Department, the Colonel urged the universities to "stick to their knitting" and to avoid wasting energy or man power on wartime "glamour courses" designed to attract students rather than to serve actual military needs. He urged concentrated attention on basic technical education, on the necessity for a higher standard of quality in scholastic achievements than would be tolerated in peace time, and on the crying need for discipline and for training the individual to participate effectively in a highly disciplined organization. In emphasizing this latter point, the Colonel pointed out that a survey made by the General Staff showed that college men, more than any other men were weak in conforming to Army discipline and had more personal distress and difficulty in adjusting themselves to camp life and Army procedure. The Colonel stated that at the present time the Army is acutely in need of leaders and that what it wants from the colleges and universities is good officer-candidate material having the basic capacity for leadership, especially the capacity to learn. He expressed the hope that the colleges would do everything possible to provide men sound and hard in body, capable of reaching and executing decisions, capable of patient foresight, endowed with a fighting morale and above all with *character*. He urged compulsory physical training as one of the most valuable elements in any premilitary educational process.

The Navy's new and comprehensive preinduction program of collegiate work was presented by Doctor J. W. Barker of Columbia University, who is now serving as special assistant to the Assistant Secretary of the Navy. The essential substance of this program is presented in some detail on pages 218–19. It seemed to be the kind of program for which those attending the Chicago conference had been waiting, for the conference promptly adopted resolutions embracing and endorsing the program, and responded to Doctor Barker's request for assistance in its development by suggesting members for a committee of five to work with the Bureau of Navigation Division of Training. This group includes President Robert L. Stearns of the University of Colorado, President R. A. Kent of the University of Louisville, Assistant Dean B. N. Dell of Princeton (Liberal Arts), Elliott D. Smith, chairman of the Economics Department at Yale University, and Father E. V. Stanford of Villanova University. Within a week this group was in Washington working with the Division of Training and the Navy Department Bureau of Navigation in the development of specific curricula and in establishing general policies and procedures representing the college side of the proposed joint educational program.

# Functions of Selective Service Discussed by Colonel McDermott

At a dinner meeting of the Alumni Association of the Polytechnic Institute, Brooklyn (N. Y.), March 11, 1942, Colonel Arthur V. McDermott, director of Selective Service for New York City, outlined the functions of Selective Service and discussed its operating procedures in some detail. Because of the wide interest in this subject at the present time, and because of the many common misconceptions concerning occupational deferments, a portion of Colonel McDermott's address is reproduced here.

"The function of Selective Service is to provide man power for the armed forces of the nation, but in exercising this function its guiding principle is to do so with the least possible disruption of the social and the economic life of the nation.

"The local boards, before classifying a man as available for general military service, are first required to determine whether he should be granted an occupational deferment in class II, because of his necessity to the defense program, or to the welfare of the community, or whether he should be granted a dependency deferment in class III, because of the needs of his wife or family. There is a fourth deferred class covering a variety of cases. It begins with public officials and winds up with those who are mentally, morally, or physically unfit for any kind of service. Comparatively few registrants are placed in class IV . . .

### OCCUPATIONAL DEFERMENTS

"As to class II, covering occupational deferments, there appear to be a great many popular misconceptions. In the first place it is not essential that a registrant be engaged directly in the production of guns or ammunition or war supplies to warrant an occupational deferment. Class II comprises two distinct categories: first, those who are 'necessary men' in pursuits which are essential to the national health, safety, or interest; second, those who are 'necessary men' in war-production industries.

"The impression also seems to prevail on the part of others that the mere fact that a man is employed in one of those pursuits, automatically entitles him to a deferment, no matter how high or low his station might be. By way of example, during recent weeks announcements were made by national headquarters of the Selective Service System that the motion-picture industry, the press, and the field of labor relations were pursuits which were conducive to the national interest and welfare, and that 'necessary men' engaged in those pursuits might be granted deferments if the circumstances appear to warrant it. Many people, including some of our most gifted editorial writers, immediately assumed this to mean that every single man engaged in those vocations was to be given a deferment. Any such assumption is absolutely incorrect. No man in those occupations or in any occupation conducive to the national welfare may be deferred unless it is *convincingly* established to the satisfaction of his local board that he is a 'necessary' man. A 'necessary' man is defined by the Selective Service regulations as one who cannot be replaced because of a shortage of persons with his particular qualifications, and whose removal would result in a serious loss of effectiveness or production in the industry in which he is engaged.

"Consequently, whether a man be a moving-picture star, a managing editor, a labor-union leader, a highly paid executive, or anything else from office boy to chairman of the board of directors, he may not be deferred unless it can be proved to the satisfaction of his local board that no one can replace him.

"Furthermore, even though a man is found to be temporarily irreplaceable, his deferment must be limited to a definite period, not exceeding six months. At the end of the period specified, he or his employer must appear before the members of the local board and convince them that every reasonable effort has been made to obtain a replacement without success. In the absence of such proof, that man will be called for induction into military service if no other grounds for deferment exist.

"A serious problem now confronts all of our large industrial plants engaged in war production. During 1941, because of their tremendous expansion, they employed tens of thousands of able-bodied young men of military age as apprentices. We cannot necessarily criticize them for that. The nation was at peace and there seemed to be a fairly ample supply of men for the needs of both industry and the Army. Many of those able-bodied young men have now become skilled workers. Their immediate wholesale removal from industry would unquestionably result in a decrease of production.

"But they *can* be and eventually they *must* be replaced by others not qualified for military service. Older men, men with physical defects, men with dependents—and, above all, women—must be trained to do their work. Today we are at war. We have a specific program for an army of at least 3,600,000 men by the end of this year. We do not know how many more we will need in the future. We do not know what lies ahead of us. The Army may eventually need every able-bodied man now in the country, and the Army comes first. Every able-bodied man who is now essential to industry will be left at his job until he *can* be replaced, but sooner or later, and with all possible speed, he *must* be replaced.

"No one can predict how many armed men we are going to need to finish this job, but this one thing we do know—that we are going to take into the Army and the Navy and the Marine Corps and the Air Forces just as many men as *are necessary to win this war*. . . . .

DEPENDENCY DEFERMENTS

"In discussing the question of dependency deferments, it would be idle for me to attempt to lay down any dogmatic statement which would serve to help you find the definite answer to your individual problems. Such an infinite variety of factors enters into each of these hundreds of thousands of cases, that no hard and fast rules will work. Each case must be decided on the basis of the individual facts involved. Once again, the final answer rests in the wisdom and the good judgment of your neighbors who are sitting as members of your local board. They will apply the general principles established by the regulations to each particular case with conscientious and patient consideration, and with due regard to the respective needs of the armed forces and of those who are claimed to be dependents. . . .

"In applying those principles, Section 622.31 of the regulations enjoins the local boards as follows:

'The local board should determine all questions of class III-A deferments with sympathetic regard for the registrant and his dependents. Any reasonable doubts in connection with dependency should be resolved in favor of deferment, and in doubtful cases the local board should be mindful of injuries which may be expected to result from separating a father from his children or a husband from his wife. The maintenance of the family as a unit is of importance to the national well-being.

'The local board should be diligent in preventing registrants from evading military service where their status with respect to dependents does not warrant their deferment, but the local board must be equally diligent in making its classifications to protect the registrant's dependents.'

"What the future may bring with respect to dependency deferments no one can foretell. A future crisis may necessitate the calling of *all* able-bodied registrants to the colors and the providing of support for their dependents by the community or the nation. Legislation is pending in Congress today with respect to increases in the pay of enlisted men and for compulsory allotments out of their pay to their dependents supplemented by an additional allowance from the Government. Such legislation and the uncertainties of the future may put an entirely different complexion on this entire dependency question, and may lead to drastic revisions in the provisions of the Selective Service Act and the regulations."

# Industrial Safety and the War Effort

In August 1941, President Roosevelt asked the National Safety Council to head an intensified nation-wide campaign against accidents, which constitute a serious hindrance to industrial production. The Council enlisted the co-operation of many national organizations, including AIEE, and an initial emergency safety conference was held September 9, at which some 100 national organizations were represented (*EE, Oct. '41, p. 510–11*). Events since December 7 have given a new and vital meaning to the emergency safety campaign, and co-operative safety efforts must now be geared to meet the impetus of war production. One of the latest steps taken by the Council in carrying out the campaign is the preparation of a report outlining the essential steps that should be followed in organizing and maintaining an industrial safety program, particularly under the stress of present conditions. Essential substance of the report follows.

In every industrial organization there should be some one appointed to head up the safety program. If the plant is too small to support a full-time safety director, then a responsible individual in the organization should be assigned to the work. In some smaller organizations, the manager himself takes charge.

The initial job of the man in charge of safety is to conduct an analysis of past plant-accident reports and records. These should bring to light certain salient facts:

First, departments should be rated according to their accident experience, thus giving a clue to where intensive corrective efforts should begin.

Second, conditions, agencies, and practices causing accidents are found, and here, also, immediate steps for improvement may be taken.

Third, the weak and strong points of certain foremen and supervisors, as they relate to accident prevention, are found. When additional education in safety is indicated, the safety director knows where to direct his earliest efforts.

Fourth, individual workers suffering repeated injuries are discovered. With this information available, the safety engineer may determine the causes for these accidents—whether due to physical handicaps, wrong mental attitudes, or lack of training or skill.

Too much emphasis cannot be placed upon organizing and maintaining a complete injury reporting system. To the safety man, the use of plant accident statistics can be as valuable as the cost sheet is to the production manager.

Extensive plant inspections should be made, to include machines, tools, fire hazards, fire protective facilities, electrical hazards, chemicals, lighting, ventilation, and housekeeping. All material-handling equipment, tools, ladders, and power-transmission apparatus should be thoroughly checked. The safety man should assist in this work, but should place considerable responsibility on foremen, supervisors, and employees.

Inspection supplements accident record analysis in locating unsafe conditions and accident causes. Many of these conditions can be eliminated at the source by careful examination of plans and specifications for all new equipment and processes. It is important that guards be included in the design of machines; state safety laws complied with; and design in conformity with accepted safe practices.

Similarly, purchase orders for equipment and materials should be checked. Specifications should cover approved safety devices and guards, and only those machines fully protected or equipped with necessary safety devices should be purchased. Certain materials purchased for use in the plant may present serious hazards of flammability or toxicity. To minimize health and injury hazards, provision must be made for the safe storing and handling of such materials.

Control through plant layout and design can be a most important factor in preventing injuries to employees and damage to equipment. In a plant where pedestrian and truck traffic is heavy, the location and size of aisles and the situation of machines at work areas are often determining factors in the accident experience. When new buildings are erected, these factors can easily be provided for, but in existing plants the problem may be more difficult.

One of the most important activities of management in the control of accidents is the elimination of mechanical hazards. Many serious injuries are due directly to lack of mechanical safeguards. If the frequency and severity of accidents are to be reduced, guards and safety devices on mechanical power-transmission equipment, on moving parts of machinery, at points of operation, on open-sided floors and working platforms, and the like, are essential.

In the course of normal plant operations, many workers are subject to serious hazards that cannot be fully eliminated by mechanical guards. Workers engaged in handling materials, electricians, welders, polishers, and grinders, mechanics, furnace men, and many others need such additional protection as is provided by personal protective equipment.

In handling certain types of material, employees can be protected by wearing

goggles, safety shoes, shin guards, protective hats, and gloves. Electricians need rubber gloves, rubber blankets, line hose, and similar equipment. Welders need face masks, aprons, and gloves; grinders and chippers and many other employees need goggles.

Intensive efforts should be made to secure the wholehearted co-operation of workers in the safety program. An appeal for this co-operation may be communicated by personal letters from management; through bulletin-board announcements; departmental meetings; or at meetings of employees. Wide publicity should be given the effort, and every means at the disposal of management used to arouse interest and a desire for co-operation.

It is extremely important that management be kept informed on progress made. Furthermore, it is advisable that the plant manager attend safety meetings from time to time, not only to encourage others by his presence, but also to keep in touch with the work.

Highly important is the organization of plant safety committees. These generally consist of a general safety committee, a foremen's safety committee, and an inspection committee.

The general safety committee should be the policy-forming group in matters affecting plant safety. Its membership may vary from four to any greater number, but it should always be made up of an executive, a foreman, a worker, and the man in charge of safety. Meetings should be held at regular intervals, usually once a month, and records should be kept of the proceedings.

The foremen's safety committee is a working committee that applies the general program directly to problems in the department. The membership is composed principally of foremen, but it is always desirable to have several workmen in the group. The plant inspection committee consists usually of a foreman and two workmen who make weekly or monthly inspections of the plant for the purpose of discovering and having corrected unsafe conditions and practices.

The reports of the inspection committee should be reviewed, and the necessary action ordered on each recommendation. All recommendations made by state departments or insurance representatives also should be reviewed and appropriate action taken. New safety rules should be discussed and, in addition, each committee member should contribute practical suggestions that will form the basis of other safety rules which will eliminate unsafe practices or conditions.

All committee members should utilize in their own work, and pass on to other employees, the safety information they gain at meetings. Foremen can usually do this through personal talks with small groups or with individuals in their departments.

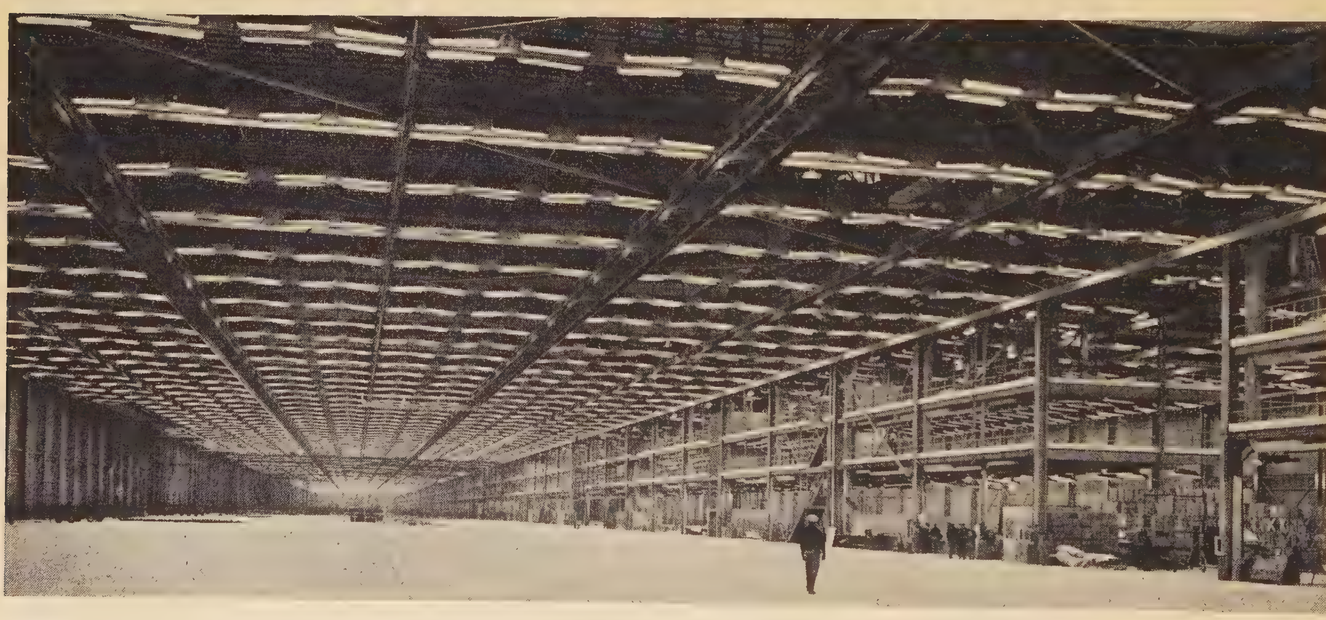
The supreme objective of a safety program at this time is to assist our war effort. Bring industrial workers to realize that every accident, whether in the plant, on the highway, or in the home, is a man lost from the production army. Show them that continued, regular production is their contribution to the maintenance of our way of life. Challenge them to exhibit their patriotism by avoiding accidents.

### How Small Manufacturers Can Get War Work

"The biggest mistake any manufacturer can make is to assume he hasn't a chance of getting war contracts," says the Division of Industry Operations of the War Production Board in a set of recommendations recently issued to help qualified small and medium-sized manufacturers. By making full use of the administrative machinery set up by WPB and supplementing it with determination and ingenuity, many manufacturers will bridge the gap—often a wide one—between nonessential and essential production. The WPB recommendations follow.

"A complete survey of his facilities is the first step of every manufacturer who wants war work. This survey should begin with the firm's business record and should include a description of normal products

## Huge Bomber-Assembly Plant Speeded to Completion



**Started April 18, 1941, construction on this huge bomber-assembly plant in Texas recently was completed. Built of fiber glass and steel, and windowless, the building is taller than a six-story apartment house and nearly a dozen city blocks long. This plant and an identical structure several hundred miles away are said to be the two largest air-conditioned buildings in the world. The heavily insulated walls also are expected to absorb 75 per cent of all factory noises. Light fiber glass lining the sidewalls and ceiling and a white cement floor assure maximum light reflection throughout the working area, which is completely equipped with fluorescent lighting. The wide assembly line shown in this view extends the entire length of the structure and has 40-foot clearance. The Austin Company, builders of the structure, recently presented merit awards to 8,552 workers in recognition of their part in speeding the completion of the plant.**

made in the plant, the experience of managerial and supervisory personnel, previous war-production experience, a financial statement, and names of past and present customers for reference.

"The manufacturer should take stock of his labor situation. In the survey he should list the number of his factory employees, their skills, peak employment of the plant for one, two, and three shifts, a description of the available labor supply and the competition for it, and a brief analysis of existing and nearby wage rates.

"Then he should take stock of the plant and its equipment, describing location, transportation facilities, available power and water facilities, and similar production factors.

"Complete layout plans, accompanied by photographs, should be made of each section of the plant. Finally, a list of all tools should be drawn in which the type, make, age, size and serial number, as well as the tolerances usually followed, are included.

"Since the survey is to serve as a guide both to himself and to those from whom the manufacturer must get his contracts, it must be accurate and complete. Since a complete survey is often expensive, the manufacturer ought to make full use of it.

"His survey will do him most good at the following places:

"1. The nearest field office of the Contract Distribution branch of the WPB. (There are 115 offices scattered throughout the country.*) Here a manufacturer can learn what war items are needed and get an idea of which he can make. He can study blueprints and samples. At some offices he will see exhibits of needed bits and pieces in which the prime contractors display actual parts and subassemblies they may want to farm out. Since the offices serve as a clearing house of information for Government procurement offices and prime contractors, the manufacturers should keep in close touch with the office serving his district.

"2. The Army's district procurement offices. By writing to the Office of the Under Secretary of the War Department in Washington, the manufacturer may get a copy of "Army Purchase Information Bulletin" which contains the addresses of the various procurement offices, the type of products they buy and the procedure to be followed in getting orders.

"3. The Navy's Bureau of Supplies and Accounts. A booklet, "Selling to the Navy" is just what its title indicates and may be obtained by writing the Bureau at the Navy Department, Washington.

"4. Local prime contractors. As firms which now have contracts become more and more 'loaded' they will become increasingly interested in the facilities of every plant that can help them fill their contracts. Addresses and other information can be obtained by bona fide manufacturers at Contract Distribution Offices.

"It must not be assumed there is any formula which will bring war work to all manufacturers, however eager they are to get it, with whatever zeal they pursue it. Harnessing the capacity of small, medium-sized, and even large factories is one of the toughest production problems America faces, and there are many complicating factors.

"One is that, because of the extreme urgency of stepping up production immediately, it has been necessary to place contracts with firms which were prepared to fill them—those which were already in war work, but whose capacity was not being utilized to the utmost. Another is the limitation in the kinds of work many of the firms without war contracts can do. One of the most important factors is the simple truth that until the attack on Pearl Harbor, America was not spending enough money on the war effort to employ the maximum capacity of all its industries.

"Recently, Congress has appropriated additional billions of dollars—and it is now appropriating billions more—for further war orders. Prime contracts are being placed with mass-production industries as fast as committees representing them can be called together for conferences with the WPB Division of Industry Operations and the Government procurement agencies.

"Firms receiving prime contracts will need thousands of subcontractors to help them meet early delivery dates. . . . About 92 per cent of the 185,000 manufacturing plants in the United States have 100 or fewer employes, and they normally produce about 31 per cent of the manufactured products. In order that as much as possible of this capacity be utilized, each plant must take on a maximum of the toughest work it can handle, leaving less difficult operations for those firms which otherwise would not be able to use their facilities. . . ."

* A list of field offices was published in the February issue, pages 99–100; additional offices have since been established.

## WPB Bureau of Industry Branches Reorganized

Reorganization of the bureau of industry branches of the Division of Industry Operations of the War Production Board has been completed by Bureau Chief Philip D. Reed, according to a recent WPB announcement. Several of the industry branches in the bureau have been divided, and the total number is now 24. Mr. Reed's top staff now consists of Amory Houghton, deputy bureau chief; John R. Kimberly and Joseph R. Taylor, assistant bureau chiefs; W. B. Murphy, N. G. Symonds, and Ben Alexander, special assistants; M. J. Dodge, Jr., executive assistant.

Among the 24 branches, with the chiefs in charge, are the following:

Rubber and rubber products—Arthur Newhall.
Special industrial machinery—Lewis S. Greenleaf, Jr.
Construction machinery—A. Stevenson (acting).
Air conditioning and commercial refrigeration—J. M. Fernald.
Transportation—A. Stevenson.
Communications—Leighton Peebles.
General industrial equipment—Charles S. Williams.
Safety and technical equipment—H. T. Rosenfeld.

The main task of each branch chief is to bring about maximum use of existing industrial capacity within the industry assigned to him for the production of war materials and products for essential civilian use. He will assist the industry assigned to him in every phase of its production program, including conversion, financing of new or expanded facilities, problems of labor supply, and procurement of materials and equipment.

The branch chief serves as the focal point for all WPB business of the industry assigned to him. In this connection, he is the official point of contact between WPB and all committees or subcommittees of such industry; and he provides the point of contact with industry for the Division of Civilian Supply in connection with its estimates of minimum civilian requirements, and recommendations of programs for the allocation of products among competing civilian demands.

The staff of each branch chief is to include one or more newly assigned representatives of the production, purchases, civilian supply, labor, legal, statistics, and materials divisions of the War Production Board, and one or more duly assigned representatives of the bureau of priorities and the bureau of industrial conservation of the Division of Industry Operations. Representatives may also be assigned from the armed services and other government agencies.

## Underwriters Adopt Emergency Specifications

Emergency alternate specifications have been put into effect by Underwriters' Laboratories to help relieve scarcities of certain materials during the emergency, according to a recent announcement. The Federal Specification Board, says the announcement, has stipulated in many of its specifications and purchase requirements that labeling and approval of products by Underwriters' Laboratories is prima facie evidence of compliance with those specifications. In view of this, and since the Federal Government, one of the largest buyers in the world, and the electrical industry, one of Underwriters' Laboratories' largest clients, were among the first to feel the impact of priority restrictions, it became imperative some time ago for the Laboratories to establish a procedure for the recognition of emergency alternate materials for electrical products. This has been done also for many of the other products approved by the Laboratories.

It was decided that after proper investigation certain substitutes not previously allowed under Underwriters' Laboratories' standards would be recognized, but that this recognition would cease when the emergency is past. Further it was decided to recognize whatever substitutes are formally announced as emergency alternatives in the Federal specifications insofar as they apply to products tested by the Laboratories.

## Production-Requirements Plan Proving Effective

In less than two months after the production-requirements plan went into effect, more than half again as many applications were received as during $7^1/_2$ months under the defense-supplies rating plan, which was replaced by the former January 1, ac-

cording to a recent announcement of the War Production Board. The greater flexibility of the production-requirements plan has attracted over 4,000 applicants, and more than 2,500 companies and divisions of companies are now actually operating under the plan.

The production-requirements plan makes it possible for the War Production Board to give consideration in granting priority assistance to the complete pattern of operations of a company or a plant, instead of treating every priority application on a piecemeal basis. At the same time, the information furnished by applicants on Form PD-25A is of great value to WPB as an indication of the general materials requirements and production facilities of American manufacturers.

The production-requirements plan is becoming increasingly useful as the number of companies handling war or essential civilian orders bearing preference ratings grows. Under this plan such firms may avoid the necessity of applying for or extending a large number of separate preference ratings by making a single application for priority assistance covering their materials requirements for a calendar quarter. On the basis of information supplied on Form PD-25A, they are given a rating or ratings to assist them in obtaining the kinds and quantities of materials and supplies needed for three months' operations in war and essential civilian production. (A revised Form PD-25A recently was issued and is now in use.)

The usefulness of the plan is indicated by the fact that one of the largest corporations in the United States has submitted applications covering 88 of its divisions and plants which have combined annual sales of $846,800,000. However, about 20 per cent of the applications received have been from companies with an annual volume of business amounting to less than $100,000. For their benefit, a simpler form of application known as the modified production-requirements plan was announced January 27, 1942.

### Positions to Be Filled Through Civil Service Examination

Notice of the following positions, which will be filled through civil service examinations, is published here as a service to members of the Institute. Application forms and full information as to requirements for examinations may be obtained from the secretary of the Board of United States Civil Service Examiners at any first- or second-class post office, or from the United States Civil Service Commission, Washington, D. C.

*Radio Inspector.* Salaries range from $2,000 to $2,600 a year. The maximum age is 45 years. Applications for the written test on radio and electrical engineering must be filed with the Commission's Washington, D. C., office not later than April 21, 1942. For assistant positions ($2,000 a year), completion of a four-year college course in electrical or communication engineering or physics is prescribed. Provision is made for the substitution of radio engineering experience for this requirement. To qualify for the $2,600 positions, applicants must have had in addition at least one year of appropriate radio engineering or teaching experience, or one year of graduate study in communication engineering. All applicants must be able to transmit and receive messages in the International Morse Code. Applications will be accepted from senior students in electrical or communication engineering or physics, or from graduate students in communication engineering, if their courses will be completed by October 1, 1942. The duties of these positions involve radio inspection work of all kinds, including inspecting radio equipment on ships, aircraft, and at various land stations to determine compliance with Government specifications.

*Metallurgists.* For work in Government navy yards, arsenals, and other war agencies. The positions pay from $2,000 to $5,600 a year and will last in most cases for the duration of the war. Experience in metal working industries with fabrication processes such as welding, die-casting, heat treating, X-ray testing, and metallographic work is particularly desired, but not necessary for all positions. College training in metallurgy or college training in other subjects and one year's experience in metallurgy will qualify for positions paying $2,000 a year. For the higher salaried positions, some industrial experience, or graduate study, in addition to a bachelor's degree, is required. Positions are in Washington, D. C., and in Government war establishments throughout the country.


**Designated as the electrical industry's own victory "V," this insignia is being offered by the St. Louis (Mo.) Electrical Board of Trade for the use of the industry in general, with the specification that it be used solely as an "industry stimulant." The design was developed and first used in advertising by the James R. Kearney Corporation, St. Louis, which recently made over full rights to the Electrical Board of Trade. Electrotypes for printing posters, stickers, and windshield stickers, may be obtained at cost; information and prices will be supplied on request by C. H. Christine, secretary-manager, St. Louis Electrical Board of Trade, 1205 Olive Street, St. Louis, Mo.**

## JOINT ACTIVITIES

### Progress in Electrical Standards Reported by ASA Committee

Important work on many phases of electrical engineering during 1941 is shown by the recent reports of technical committees to the Electrical Standards Committee of the American Standards Association. The Committee, in which the AIEE is a participant, reports that 4 new standards and 16 revised standards developed by its subcommittees have been approved by the ASA during the past year.

Among the more important standards on which significant progress has been made are the Definitions of Electrical Terms, prepared under AIEE auspices, which was completed and approved in 1941 and is in process of publication; the standard for transformers, published in 1940 for a year's trial use, and now being put into shape for final approval; and the standard for circuit breakers, published in 1941 for a year's trial.

Officers and members of the executive committee of the Electrical Standards Committee, re-elected for 1941–42, are:

C. R. Harte (M'32) chairman; Sidney Withington (F'24) vice-chairman; J. W. McNair (A'25) secretary; L. F. Adams (M'26) representing the National Electrical Manufacturers' Association; R. E. Hellmund (F'13) representing the AIEE; P. H. Chase (M'18) representing the Electric Light and Power Group; A. R. Small (M'37) member-at-large; H. L. Huber (M'23) member-at-large.

## LIBRARY

### Library Service for AIEE Members

For Several years the privilege of borrowing books from the Engineering Societies Library in the Engineering Building at 33 West 39th Street, New York, N. Y., has been available to Institute members. Many members have made use of this service. Books have been sent to all parts of the United States, in steadily increasing numbers. To encourage a more extensive use of this service, the board of trustees of the Library recently reduced the fee charged to cover mailing and other costs involved in this remote-member service.

Under present rules, the Library will loan up to three books at a time to any member anywhere in the United States or Canada at a total charge of 25 cents per week per volume, with a maximum rental period of two weeks exclusive of shipping time. Except for rare and irreplaceable books, and purely reference works, such as dictionaries and handbooks, any of the several thousands of treatises and text books stored in the Library's several floors of shelves may be borrowed. As the Library is equipped to supply photostat and microfilm copies of periodical articles, periodicals are lent only when bound and then only when such reproductions will not answer the inquirer's need.

This Library, jointly sponsored by AIEE and the other Founder Societies, is one of the largest technical libraries in the world; in most cases a member need only name the title he requires to find it in the Library. Or, a member may file an inquiry with the Library concerning a subject in which he is interested and the Library will inform the inquirer as to the various works available pertaining to the subject of his inquiry. The Library has issued no printed catalog

of its vast stocks, partly because of the cost and the rapid obsolescence of any such catalog, and partly because the new acquisitions to the Library shelves from month to month are published in *Electrical Engineering* and in the monthly periodicals of the other participating societies, in accordance with the nature of the subject matter.

# OTHER SOCIETIES

## New Memorial Building Houses Engineering Society of Detroit

The Horace H. Rackham Educational Memorial was recently completed as the headquarters for the Engineering Society of Detroit, and the Detroit offices of the University of Michigan Extension Service and Institute of Public and Social Administration. The building is located in Detroit's Art Center, and with its grounds occupies a city block. It contains an auditorium seating 1,000, and a banquet hall seating 650, both of which will be used jointly by the Engineering Society and the University. The Engineering Unit includes administration offices and meeting rooms for the Society and affiliated technical societies, library, auditorium seating 500, dining room, lounges, and recreation rooms. The University unit includes classrooms, a radiobroadcasting studio, library, and offices.

The Engineering Society of Detroit was organized in 1936, succeeding the former Detroit Engineering Society. Local chapters of various national engineering and architectural societies, including the Michigan Section of the AIEE, are affiliated with it. In 1936 also, the Rackham Engineering Foundation was incorporated as a trustee organization to administer the grants, totaling $1,000,000, made from the Horace H. Rackham and Mary A. Rackham Fund to the Engineering Society of Detroit for the purpose of erecting the building.

## Future Meetings of Other Societies

**American Chemical Society.** April 20–24, 1942, Memphis, Tenn.

**American Institute of Chemical Engineers.** 34th semiannual meeting, May 11–13, 1942, Boston, Mass.

**American Physical Society.** 249th meeting, June 25–27, 1942, State College, Pa.

**American Society of Civil Engineers.** Spring meeting, April 19–23, 1942, Roanoke, Va.

**American Society for Testing Materials.** 45th annual meeting, June 22–26, 1942, Cleveland, Ohio.

**American Society of Mechanical Engineers.** Semiannual meeting, June 8–10, 1942, Cleveland, Ohio.

**Edison Electric Institute.** Annual convention, June 1–4, 1942, Atlantic City, N. J.

**Electrochemical Society.** Spring convention, April 15–18, 1942, Nashville, Tenn.

**Institute of Radio Engineers.** Summer convention, June 29–July 1, 1942, Cleveland, Ohio.

**Midwest Power Conference.** 5th annual meeting, April 9–10, 1942, Chicago, Ill.

**National Electrical Manufacturers Association.** May 10–15, 1942, Hot Springs, Va.

**National Fire Protection Association.** May 11–15, 1942, Atlantic City, N. J.

**Society of Automotive Engineers.** Semiannual meeting, May 31–June 5, 1942, White Sulphur Springs, W. Va.

**Society for Promotion of Engineering Education.** Annual meeting, June 29–July 3, 1942, New York, N. Y.

# LETTERS TO THE EDITOR

**INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.**

## Voltage Calculation

*To the Editor:*

George P. Hobbs' query in the November 1941 issue of *Electrical Engineering* (page 562) may be answered on either the practical or the philosophical level. On the former level, the magnitude of the variables is all-important, a fact implied by Mr. Hobbs in his phrase, "a statistical stream of discrete charges." Since a coulomb contains about six million million million electrons, the calculus applies on a macroscopic statistical basis, within the limits of measurement. On the other hand, in Milliken's oil-drop experiment we deal with the individual discrete charges, giving rise to the stepwise changes mentioned by Mr. Hobbs, and calling for an entirely different mathematical treatment.

On the philosophical level, mathematics, being the science of pure relation, deals only with abstractions, not reality. But for practical purposes the abstraction may be highly analogous to reality. The applicability of mathematics to everyday physics depends entirely on the closeness of the analogy between the "absolute" mathematical formulas and the actual behavior. Thus the area of a round disk is taken to be $\pi r^2$, by analogy of the periphery to an ideal circle, yet we know that no disk ever made or to be made possessed a periphery satisfying the exacting requirements of the mathematical abstraction, a circle.

Examination of many macroscopically continuous phenomena reveals an ultimate discontinuity or quantization, including the large class of "continuous fluids." Time, however, is not in this group, and is pretty much of a mathematical abstraction itself, as may be found in attempting accurately to describe it.

ELLIS BLADE

(Consulting engineer, New York, N. Y.)

*To the Editor:*

In the November 1941 issue of *Electrical Engineering*, an interesting point was raised by George P. Hobbs, in his letter regarding the mathematical significance of the time derivative $dq/dt$.

It is true that the factor $q$ is not a perfect variable, regardless of the arbitrary value assigned to the fundamental unit of charge. From this standpoint, therefore, the time derivative has no exact mathematical significance, and from a rigorous point of view is only an approximation given by

$$\lim_{\Delta t \to t_1} \frac{\Delta q}{\Delta t}$$

where $t_1$ is a value of time consistent with the addition or subtraction of a unit charge.

I believe, however, that Mr. Hobbs' objection to the use of the derivative springs from the fact that the physical aspect is lost in any operational treatment which assumes a mathematical significance for the derivative.

For the purposes of the engineer however, mathematics is a means to the end that we shall obtain a physical solution to a circuit or explain a particular behavior. If we assume for the moment that the unit charge is infinitesimal, and therefore that $q$ is a perfect variable, the term $dq/dt$ assumes a rigorous mathematical status, and as such lends itself conveniently to mathematical treatment.

It is only when we assign numerical values in a particular case that we must again resort to a fundamental value of $q$. In that event the particular value of $q$, which we may call $Q$, must be evaluated, not as a point on a smooth curve of variation but as a value on a step-by-step function.

Inasmuch as the fundamental value of $q$ is small compared to the more convenient practical unit of charge, the method of treatment suffices for almost any conceivable physical solution, and we have incurred no error in our stretch of the imagination.

E. C. CHAMBERLIN (A'40)

(Chief operator, The Western Union Telegraph Company, Fort Smith, Ark.)

## Two Network Theorems

*To the Editor:*

In solving network problems, two problems are frequently met with. The first is to find the current in each of a multiple of loads connected in parallel and to be

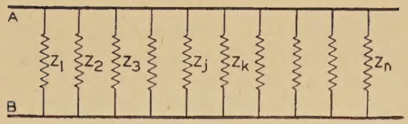



**Figure 1**


**Figure 2**

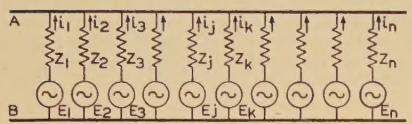



**Figure 3**

supplied from the same source. This is the problem of current distribution. The second is to ascertain the circulating current in each of several sources in parallel operation. These two specific problems can, of course, be solved by the application of the existing laws and theorems. However, their complexity will be increased as the number of meshes in the network is increased. The writer suggests two network theorems as special tools in attacking such problems. These are the current-distribution theorem and the circulating-current theorem. Both have been mathematically proved.

Before presenting the description and proof of the theorems, it is necessary to define the term "dropping factor" as it will be used. Figure 1 represents a network consisting of $n$ impedances, all connected in parallel with one another. The total impedance of the entire network as seen from the terminals $A/B$ is $\mathcal{Z}$. The dropping factor of branch 1 is defined as the ratio of total impedance $\mathcal{Z}$ to the impedance $z_1$ in the said branch. The dropping factor of branch 2 is, therefore,

$$D_2 = \frac{\mathcal{Z}}{z_2}$$

In general, the dropping factor of branch $k$ is

$$D_k = \frac{\mathcal{Z}}{z_k} = \frac{1}{z_k \sum_{n=1}^{n} \frac{1}{z_n}}$$

The properties of the dropping factor are:

1. The dropping factor is, in general, a complex quantity.

2. Since $D_j = \frac{\mathcal{Z}}{z_j}$ and $D_k = \frac{\mathcal{Z}}{z_k}$, we have

$$\frac{D_j}{D_k} = \frac{z_k}{z_j}, \text{ or } \frac{D_j}{z_k} = \frac{D_k}{z_j}.$$

3. $D_1 + D_2 \ldots + D_n =$

$$\mathcal{Z}\left(\frac{1}{z_1} + \frac{1}{z_2} \ldots + \frac{1}{z_n}\right) = 1.$$

4. When $z_1 = z_2 = \ldots = z_n$, then $D_1 = D_2 = \ldots = D_n = \frac{1}{n}$.

CURRENT-DISTRIBUTION THEOREM

When $n$ impedances $z_1, z_2, \ldots z_n$ are all connected in parallel, and electromotive force $E_k$ introduced in branch $k$ will cause a terminal voltage $V_{AB}$ equal to

$$V_{AB} = D_k E_k$$

and a current in any other branch $j$ equal to

$$i_{jk} = \frac{D_k E_k}{z_j}$$

where $D_k$ is the dropping factor of branch $k$.

*Proof:* The current-distribution theorem may be proved by Ohm's law. The total impedance of $z_1, z_2, \ldots z_n$, excluding $z_k$, in parallel, is

$$\frac{1}{\frac{1}{\mathcal{Z}} - \frac{1}{z_k}} = \frac{z_k \mathcal{Z}}{z_k - \mathcal{Z}}$$

which, when connected in series with $z_k$, becomes

$$\frac{z_k \mathcal{Z}}{z_k - \mathcal{Z}} + z_k = \frac{z_k^2}{z_k - \mathcal{Z}}$$

The current in branch $k$ due to the presence of electromotive force $E_k$ in the same branch is

$$i_k = \frac{E_k}{\frac{z^2k}{z_k - \mathcal{Z}}} = \frac{E_k(z_k - \mathcal{Z})}{z_k^2}$$

The voltage across the terminals $A$ and $B$ is

$$V_{AB} = E_k - i_k z_k$$
$$= E_k - \frac{E_k(z_k - \mathcal{Z})}{z_k}$$
$$= \frac{\mathcal{Z}}{z_k} E_k$$
$$= D_k E_k$$

Therefore the current distributed in branch $j$ due to the presence of electromotive force $E_k$ in branch $k$ is

$$i_{jk} = \frac{D_k E_k}{z_j}$$

CIRCULATING-CURRENT THEOREM

When $n$ electrical sources, having the voltages $E_1, E_2, \ldots, E_n$ and internal impedances $z_1, z_2, \ldots z_n$ are connected in parallel, the circulating current in any branch $k$ is

$$i_k = i_{sk} - D_k \sum_{j=1}^{n} i_{sj}$$

where

$$i_{sk} = \frac{E_k}{z_k}$$

is the short-circuit current of the source in branch $k$. The short-circuit currents of the sources in branches 1, 2, ... $n$ are

$$i_{s1} = \frac{E_1}{z_1},\ i_{s2} = \frac{E_2}{z_2},\ \ldots\ i_{sn} = \frac{E_n}{z_n}$$

respectively.

*Proof:* The current in branch $k$ due to the presence of electromotive force $E_1$ in branch *1*, as obtained by the current distribution theorem is

$$i_{k1} = \frac{-D_1 E_1}{z_k}$$

The negative sign here used signifies that the current $i_{k1}$ entering branch $k$ has the direction opposite to that indicated by the arrow in Figure 3. Similarly the current in branch $k$ due to the presence of electromotive force $E_2$ in branch 2 is

$$i_{k2} = -\frac{D_2 E_2}{z_k}$$

etc. But the current in branch $k$ due to the presence of electromotive force $E_k$ only is

$$i_{kk} = \frac{E_k(z_k - \mathcal{Z})}{z_k^2} = \frac{(1 - D_k)E_k}{z_k}$$

By the superposition theorem, we obtain

$$i_k = \frac{E_k}{z_k} - \sum_{j=1}^{n} \frac{D_j}{z_k} E_j$$
$$= \frac{E_k}{z_k} - \sum_{j=1}^{n} \frac{D_k}{z_j} E_j$$
$$= i_{sk} - D_k \sum_{j=1}^{n} i_{sj}$$

In an interesting special case the internal impedances of the sources are all equal. Then

$$\mathcal{Z} = \frac{z}{n},\ D = \frac{1}{n}$$

and the value of circulating current in any branch $k$ becomes

$$i_k = i_{sk} - D_k \sum_{n=1}^{n} i_{sn}$$
$$= i_{sk} - \frac{1}{nz} \sum_{n=1}^{n} E_n$$
$$= \frac{E_k - \frac{1}{n} \sum_{n=1}^{n} E_n}{z}$$

From the result obtained, it will be seen that when we have $n$ sources of unequal electromotive force but of equal internal impedances, the circulating current in any branch is equal to the difference between the electromotive force in that branch and the average electromotive force of all branches divided by the internal impedance $z$.


HENRY LING

(Chief engineer, Chekiang Telephone Administration, Lishui, Chekiang, China)

## Dual Rating of Electrical Apparatus

*To the Editor:*

A perusal of P. L. Alger's article, "The Dual Rating of Electrical Apparatus" (*EE, Dec. '41, p. 569–71*), brings many points to mind.

Assuming that of a ventilated-type short-time rated machine, the equivalent continuous rating, or what amounts to the same thing, the ratio or inverse ratio of the continuous and short-time ratings, is taken as a figure of merit, it would appear that the efficiency is implicitly involved. A machine designed for short-time rating will not require so much cooling air as it would when giving its optimum continuous output, but if the latter or any function of it were taken as a figure of merit, it would not be difficult to provide a greater quantity of cooling air at the expense of increased light load losses when the machine was working on its (normal) short-time duty.

It follows therefore that if the aim is to give the best possible efficiency at rated load, the shape of the thermal characteristic will vary with the point at which the machine is rated. In general the proposed service factor *S* would depend in practice mainly on the thermal characteristic.

Regarding the maximum torque of short-time rated machines, it is worth noting that, whereas American Standards Association publication *C*50-1936 specifies that the machine shall commutate successfully under its specified operating conditions, 100 per cent overload in torque—which results in approximately 85 per cent excess current with normal shunt characteristic—is laid down in British Standard Specification 168. Not infrequently on 15- and 30-minute rated machines, this 100 per cent excess torque requirement results in one meeting a commutation limit.

When one recollects the large number of successful applications to industrial and portable drives of the Diesel engine, one is led to contemplate whether so large a factor of safety really is necessary. An induction motor has of course an invariable limit determined by its reactance, whereas a borderline d-c machine might or might not flashover on any particular occasion requiring 100 per cent excess torque.

Again a short-time rated totally enclosed induction or shunt characteristic d-c motor might be as incapable of working continuously even at no load, as the 100-horsepower machine discussed on page 570 of Mr. Alger's article. At the same time it would be possible to arrange for a reduction in the flux by suitably laying out the terminal box in the first instance.

There is the case of the self-ventilating continuously rated machine designed for long speed range (e.g., the polyphase shunt characteristic commutator motor, the ultimate motor of a Ward-Leonard system application, or the d-c shunt characteristic motor having combined shunt field and armature voltage reductions) in which it is necessary in order to avoid fan noise and excessive windage at high speed, to rate on a short-time basis at the lower speeds of the range.

The continuous output for short-time rated series characteristic machines will be associated with a higher speed, and with the latter as normal there is the possibility of the series characteristic resulting in the mechanical safety limits being exceeded during continuous operation.

The Authority which for years probably has been the largest purchaser in Great Britain of d-c machinery has insisted that for intermittently rated machines a statement of the equivalent continuous output should be given on the name-plate as well as on the drawings.

Mr. Alger's suggestion that there should be greater consistency in the design of the various links of the chain from bus bars to motor shaft end will meet, I am sure, with universal approval.

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## Electric Shock Induced by Lightning Stroke

*To the Editor:*

On October 19, 1941, in the north end of the Steins Mountains at a point approximately 25 miles southwest of the post office of Follyfarm in Malheur County, Oregon, the writer was hunting mule deer in company with two companions. The time of day was about 10:30 a.m. and we were crossing a high, broad ridge at an elevation of approximately 6,500 feet above sea level. For several hours there had been indications of an impending storm, and now it was gathering rather rapidly. There had been no evidence of electrical disturbances and the lateness of the season seemed to minimize the probability of development of an electrical storm.

We were nearing the summit of the ridge when suddenly an apparent cloud-to-cloud discharge took place immediately overhead. The interval between flash and the audible report indicated that the path of the stroke was not more than 300 yards distant and we immediately recognized the danger of our position. At that particular point the terrain was rather flat, but we changed our course and headed for the nearest break to lessen our exposure. Other than the brilliant flash and the intense report, no physical sensations accompanied the first stroke of lightning.

We had progressed perhaps 150 yards when the second stroke occurred. We were walking in single file and approximately 25 feet apart. As a result of a previous warning, all of us were carrying our rifles horizontally and in the lowest convenient position. At the moment of this second stroke, I was conscious of the simultaneous occurrence of several things. First, there was a brilliant background flash accompanied by a burst of corona streamers from the muzzle and front sight of my rifle. I happened to be looking in that general direction and distinctly observed this phenomenon. I felt a very intense, impulsive shock in my right arm, the one that was carrying the rifle, and felt a similar shock throughout my entire body. It seemed particularly severe in the region of my neck and might be likened to a rather severe blow from a rubber hammer, centered approximately at the base of the skull. My hat was knocked from my head, and I very distinctly heard the familiar sound of the impulsive corona streamers that not only formed on the muzzle of my rifle, but also seemed to form all about my head. I was knocked or fell to my knees, but was completely conscious at all times and recovered my feet almost immediately.

I was entirely aware of what had happened and made a conscious effort to remember in detail everything that occurred. The companion ahead of me froze in his tracks for a moment and then slowly turned about with a glassy stare in his eyes. I heard a low groan from behind, and as soon as I could command the proper muscles turned toward my companion in the rear. He was sprawled full length, face down on the ground, and his rifle was lying six or eight feet from his extended arm. He seemed virtually unconscious at first, and we approached him as rapidly as we could gather muscular control. I called to him and immediately thought of applying artificial respiration. As we approached him, however, he slowly rolled over, opened his eyes, and stated that his left leg felt as if it had been broken. We helped him to his feet and he stated that his right arm, which had been carrying his rifle, and his left leg seemed to have borne the brunt of the shock.

Recognizing the further danger of our exposed position, we gathered our wits together as best we could and proceeded on toward lower ground in the most stooped attitude we could assume. Because of the flat, barren character of the terrain surrounding us, we felt safer in making a desperate attempt to get out of there than in attempting to reduce our exposure by lying flat on the ground.

Subsequent lightning strokes in this storm, which developed into one of severe intensity and considerable extent, particularly at the lower altitudes, seemed more than 500 to 1,000 yards distant.

The evidence seems to indicate that, at the time we received our severe shock, a lightning stroke probably terminated on the ridge in our near vicinity and heavy streamer currents passed upward from the ground through our bodies. There is a second possibility that a cloud-to-cloud discharge occurred and that the sudden increase in potential of the cloud immediately above us caused heavy displacement currents to flow through our bodies. The corona streamers developed as a result of the suddenly increased voltage gradient in the space between the cloud and ground. A third possibility is that the release of a "bound charge," resulting from the discharge of a cloud immediately overhead, gave rise to the impulsive corona streamers and the accompanying shock.

In any event, the magnitude of the shock, particularly in the case of the second companion, approached very closely the intensity required to produce paralysis. I feel particularly fortunate in having escaped

a direct stroke, or a critically severe induced stroke. However, from a professional angle, now that the experience is over, I should regret having missed it. The one outstanding impression that I have retained since the moment of the experience is the perfect similarity between the sound of the corona streamers that burst all about my head and those that are produced by a suppressed discharge in a large sphere gap. The shock seemed very similar to that obtained from a capacitor discharge. Careful inquiry revealed that my companions could recall details exactly similar to those outlined.

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## NEW BOOKS • • •

**Civil Air Defense.** By Augustin M. Prentiss. Whittlesey House, McGraw-Hill Book Company, New York and London. 334 pages, 6 by 9 inches, illustrations, etc., cloth, $2.75.

A handbook by a lieutenant colonel of the United States Army on the protection of the civil population against air attack, aiming to present the best available information for the use of state and municipal authorities, industrial and business employers, and individuals. Data are based on practices being followed in European cities. Types of air attack and the effects of each are discussed, protective devices are described, and organization, training, and methods of procedure for defensive services are suggested.

**ECPD Annual Report.** Engineers' Council for Professional Development, 29–33 West 39th Street, New York, N. Y. 48 pages, paper, 25 cents.

Report for the year ending September 30, 1941, containing the reports of the chairman, the standing committees, and the representatives of constituent organizations. Accredited undergraduate engineering curricula, the financial statement, and a report of the annual dinner are included as well as a list of officers, representatives, and committee personnel and the charter and rules of procedure.

**The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.**

**These and thousands of other technical books may be borrowed from the library by mail by AIEE members.**

**Table of Natural Logarithms.** Volume 3. Logarithms of the Decimal Numbers from 0.0001 to 5.0000. By the Federal Works Agency, Work Projects Administration for the City of New York, conducted under the sponsorship of the National Bureau of Standards, Washington, D. C., 1941. 501 pages, tables, etc., 11 by 8 inches, cloth, $2.00, payment in advance.

This volume, the third in a series of four, contains the values to 16 decimal places of the natural logarithms of the decimal numbers from 0 to 5 at intervals of 0.0001. Methods for interpolation and inverse interpolation are given.

**Elliptic Cylinder and Spheroidal Wave Functions.** Including Tables of Separation Constants and Coefficients. By J. A. Stratton, P. M. Morse, L. J. Chu, and R. A. Hutner. A publication of the Technology Press, Massachusetts Institute of Technology; John Wiley & Sons, New York; Chapman & Hall, London, 1941. 127 pages, illustrated, 11 by $8^1/_2$ inches, paper, $1.00.

This publication attempts to define certain standard forms of the solution of the wave equation, and presents a collection of formulas giving the important mathematical properties of certain elliptic and spheroidal functions. There is also a set of tables from which values of the solutions can be obtained for the more interesting ranges of the variables. The intention is to increase the practical use of these mathematical tools.

**ASTM Standards on Rubber Products.** By *ASTM* Committee D-11 on Rubber Products. December, 1941. American Society for Testing Materials, Philadelphia, Pa., 1941. 280 pages, illustrated, 9 by 6 inches, paper, $1.75.

This annual publication gives in their latest approved form the specifications and methods of testing adopted by the Society. Among them are several new standards and numerous revisions of earlier ones. There is also a bibliography on the properties and testing of rubber.

**1941 Supplement to ASTM Standards, Including Tentative Standards.** Part 1. Metals. 597 pages; Part 2. Nonmetallic Materials—Constructional. 427 pages; Part 3. Nonmetallic Materials—General. 641 pages. American Society for Testing Materials, Philadelphia, Pa., 1941. Illustrated, $9^1/_2$ by 6 inches, cloth, $3 for any one part, $5 for any two parts, $7 for all three parts.

To keep up to date its triennially published Book of Standards, the American Society for Testing Materials publishes, in the two intervening years, supplements to each of the three volumes of that set. This 1941 supplement gives in their latest approved form the 370 specifications, tests, and definitions either revised or issued for the first time in 1941.

**Elementary Plane Surveying.** By R. E. Davis. Second edition. McGraw-Hill Book Company, New York and London, 1941. 464 pages, illustrated, $7^1/_2$ by $4^1/_2$ inches, cloth, $3.00.

This text is prepared for students of architecture, forestry, electrical and mechanical engineering and others who wish a short course in the subject. It combines a classroom text and a manual of field and office exercises and is designed for a one-semester course. The new edition has been entirely rewritten, and considerable new material added.

**Arms and the Aftermath.** By P. Stryker. Houghton Mifflin Company, Boston, 1942. 157 pages, tables, $8^1/_2$ by $5^1/_2$ inches, cloth, $1.75.

An attempt is made to indicate the meaning of industrial mobilization, the importance of effective mass production methods, the results of the change-over and the tremendous financing problems for rearmament. Aims to give the reader a behind-the-scenes view of the causes, functioning, and effects of the mobilization of industry for the war effort.

**Plant Production Control.** By C. A. Koepke. John Wiley and Sons, New York; Chapman and Hall, London, 1941. 509 pages, illustrated, 9 by 6 inches, cloth, $4.00.

With the objective of securing the maximum production of goods with minimum confusion and expense, production control is broken down into its several functions, each being treated separately, yet co-ordinated with the others to show how control of production is obtained for various situations. Review questions and a short bibliography accompany each chapter.

**The Welding Encyclopedia and the Welding Industry Buyers' Manual.** Compiled and edited by L. B. Mackenzie and H. S. Card; re-edited by S. Plumley. Tenth edition. Welding Engineer Publishing Company, Chicago, Ill. 712 pages, illustrated, 9 by 6 inches, fabrikoid, $5.00.

The subject matter is arranged alphabetically, and all relevant illustrations and technical data are to be found directly associated with the definitions and explanations. Some of the principal topics covered are the main types of welding, the most important fields of use, metals and alloys, metal spraying, testing methods, and operator training. Company names are included with a listing of the trade names of their products.

**Dictionary of Radio and Television Terms.** By R. Stranger. Chemical Publishing Company, Brooklyn, N. Y., 1941. 252 pages, diagrams, etc., 9 by $5^1/_2$ inches, cloth, $2.50.

Designed to provide quick reference for students of radio and television. A number of allied scientific terms are also included.

**Wire and Wire Gauges.** With Special Section on Wire Ropes. By F. J. Camm. Chemical Publishing Company, Brooklyn, N. Y., 1941. 138 pages, diagrams, etc., 7 by 4 inches, cloth, $2.50.

Standard wire systems of Europe and America are set forth separately for greater ease in reference. Information on wire drawing and on the construction, use, and maintenance of wire rope is also included.